FMC Idaho LLC, Pocatello, Idaho

Volume 2 - Appendices

Supplemental Feasibility Study Report for the FMC Plant Operable Unit

July 2010

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Via Email & 1st class mail

January 16, 2009

Ms. Kira Lynch, MS ECL-113
US Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Re: Administrative Order on Consent for Supplemental Remedial Investigation/Feasibility Study for the FMC Plant Operable Unit (U.S. EPA Docket No. CERCLA 10-2004-0010)

SFS Identification and Evaluation of P4 Treatment Technologies Report
and
SFS Preliminary Remedial Technology Screening Tables

Dear Ms. Lynch:

In your September 30, 2008 letter providing comments on the SFS work plan that FMC submitted on July 15, 2008, item 2 in the general comments included the comment "EPA also recommends adding a Technology Screening Memo deliverable into the schedule prior to performing detailed analysis of alternatives for the SRI FS and finalizing the ARARs." FMC's November 2, 2008 response to EPA's comments included a SRI/SFS Target Schedule for various interim deliverables, including an SFS Technology Screening Memo by January 5, 2009. Pursuant to my voice messages over the past two weeks, and as indicated in the December monthly report, various project team health issues over the holidays resulted in a delay of this deliverable until this week, although it should be noted that the three other interim deliverables due by January 5 were submitted on schedule.

This letter transmits FMC's report titled" Identification and Evaluation of P4 Treatment Technologies" which represents a thorough review of technologies potentially applicable for remediation of solids and groundwater that are contaminated with elemental phosphorus, a description of the physical factors that affect the screening of P4 remedial technologies for potential application at the FMC Plant OU, and generally provides an update to a similar review conducted by the Office of Solid Waste and Emergency Response in 2003.

This letter also transmits the Preliminary Remedial Technology Screening Tables (Table 6.1 for soils/solids and Table 6.2 for groundwater) which have been developed based on all contaminants of concern identified at the FMC Plant OU, in addition to elemental phosphorus. During the Agencies' review of these Preliminary Remedial Technology Screening Tables, please bear in mind that these screening tables, when final, will be incorporated into the SFS report, which will include significant narrative detailing the screening process, which is merely summarized in these tables, as well as the results of the screening process. To the extent that that these tables represent FMC's preliminary evaluation, which has been conducted without documenting the screening process to support the analyses summarized in the tables, FMC has not completed the column indicating whether the technology would be 'retained' for further analyses in the SFS process. FMC believes that following agency review, and the discussion of these deliverables scheduled to occur February 25-26 in Salt Lake City, recommendations for technologies to be retained or rejected in the next steps in the SFS processes can be developed.

With respect to the agency's review of the" Identification and Evaluation of P4 Treatment Technologies" report, FMC believes that this level of rigor in examination of remedial technologies potentially applicable to elemental phosphorus is necessary at this juncture (e.g., as an early interim deliverable), not only to facilitate an efficient and effective review of the complete SFS report when prepared later this year, but also to allow for a more informed ongoing discussion of the EPA comment on the SRI report regarding the potential use of EPA's discretionary designation of principal threat wastes at the FMC Plant OU. FMC has previously commented that its adherence to the Feasibility Study process and the National Contingency Plan itself will drive the process to thoroughly evaluate treatment alternatives for elemental phosphorus, as is evidenced in the attached report, without the need for that discretionary designation. Submittal of this report demonstrates that fact. Furthermore, ongoing constructive discussion between FMC and the agency on the remedial screening process, as anticipated for our meeting in Salt Lake City, will result in assurances of adherence to the NCP and should address agency concerns which prompted consideration use of this discretionary designation guideline.

Please call me with any questions, or to discuss further.

Sincerely,

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Identification and Evaluation of P4 Treatment Technologies

January 2009

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Section 1.0 Introduction

1.1 OBJECTIVE AND SCOPE OF THIS REPORT

The Supplemental Feasibility Study (SFS) for the FMC Plant OU will present the identification, screening and evaluation of remedial technologies and alternatives for all of the COCs and media identified in the *Supplemental Remedial Investigation Report for the FMC Plant OU* (*SRI Report*; MWH, 2008). The SFS will include significant focus on options and technologies potentially effective to remediate elemental phosphorus (P4) in the subsurface due to the unique risks associated with management of P4. This report provides a summary of the process undertaken for the identification and preliminary screening of treatment technologies specific to P4 in the subsurface in advance of the SFS, to initiate discussion with EPA on appropriate options and technologies to carry forward into the detailed evaluation of alternatives.

This summary focuses on treatment technologies, both in-situ and ex-situ, for remediation of P4-impacted soils and groundwater at the FMC Plant Site. Non-intrusive remediation technologies, although they are potentially viable options, are not discussed in this report, but will be examined in the SFS screening and evaluation process. These non-intrusive technologies include the following:

- Institutional Controls – Fencing, Access Restrictions/Controls and Monitoring
- Containment – Capping and Surface Controls

In the SFS Report prepared for the FMC Plant OU, one or more of these non-intrusive remedial options may be combined to create non- intrusive alternatives for site remediation. They also may be considered as adjuncts to remedial alternatives that include active intrusion and treatment. Non-intrusive alternatives are particularly relevant when addressing P4 soil contamination due to the significant worker health and safety and environmental risks associated with active treatment of such contamination.

Ancillary process options that would be necessary to complete the overall P4 treatment train are identified and described in Section 2.0 as these are integral to the overall remedial alternatives that are evaluated here (e.g., excavation of P4-impacted soil is necessary to feed the material to an ex-situ treatment process). The processes also were evaluated with respect to their treatment of metals and radionuclides that also are found with P4-contaminated soils at the site. Note that for this document, "P4-impacted soils" is intended to include all soils and/or fill materials that are contaminated with elemental phosphorus at levels above the remedial action objective (RAO) for P4 in soils and ranging up to 50% P4 or greater.

In 2003, EPA prepared a similar report that evaluated possible treatment technologies for historic ponds at the FMC site containing P4 (in addition to metals and radionuclides). The EPA report entitled *Treatment Technologies for Historic Ponds Containing Elemental Phosphorus – Summary and Evaluation* (*2003 Treatment Technologies Report*, EPA, 2003) was used by FMC in preparation of this document. In addition, FMC reviewed pertinent information from other

elemental phosphorus sites, including manufacturing facilities, where the investigation and remediation included action for P4 in the subsurface. Table 1-1 presents a list of the commercial and military P4 sites and a summary of the remedy selected (or proposed) for the P4 soils and/or wastes, including waste ponds, at these sites. The table also indicates the lead Agency for the listed sites.

Other sources of information that were used for the identification and screening of technologies include the following:

- Review of internal FMC technical documents related to P4 experimentation, handling, neutralization, and safety practices
- Discussion with personnel at other P4 manufacturing facilities and review of technical information from these sources related to P4 treatment
- Search of Internet for technical documents related to P4 treatment

Section 5.0 of this report reviews the findings reached in the *2003 Treatment Technologies Report* and, considering the more recent information included in this summary report, reviews and updates those findings.

This summary, although not specifically required under the SRI/SFS AOC and SOW, is intended to assist in development of the SFS Report and constitutes the first step in the SFS Technology Screening Process.

1.2 REGULATORY BACKGROUND

The FMC Plant Operable Unit (OU) is a part of the larger Eastern Michaud Flats (EMF) Superfund Site, and is located in southeastern Idaho, approximately 2.5 miles northwest of Pocatello, Idaho. The EMF Site was listed on the National Priorities List (NPL) on August 30, 1990. The EMF Site includes two adjacent production facilities, a former FMC Corporation elemental phosphorus processing plant that ceased operation in 2001 and a phosphate fertilizer processing facility operated by the J.R. Simplot Company. The EMF Site is shown on Figure 1-1 and encompasses both the FMC and Simplot plants and surrounding areas affected by releases from these facilities. FMC, Simplot and EPA entered into a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Administrative Order on Consent (AOC) in May 1991 under which the companies agreed to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the site. During the RI/FS the site was divided into three "Subareas:" 1) the FMC Subarea, consisting of the FMC Plant Site (where elemental phosphorus production took place) and other FMC-owned properties at the site; 2) the Simplot Subarea, consisting of the Simplot plant and other Simplot-owned properties at the site; and 3) the Off-Plant Subarea, consisting of the remainder of the site. EPA changed these designations to the FMC Plant OU, the Simplot Plant OU, and the Off-Plant OU after its June 1998 *Record of Decision for the EMF Site* (*1998 ROD*, EPA, 1998).

FMC ceased production of elemental phosphorus from phosphate ore at its Pocatello facility in December 2001. This led EPA and FMC to enter into an AOC in October 2003 (SRI/SFS AOC) for a Supplemental Remedial Investigation and Feasibility Study (SRI/SFS) at the FMC Plant OU. This was driven primarily by EPA's finding that additional investigations and evaluations were needed at the plant areas that had been actively operated at the time of the RI/FS but where operations had terminated with the plant shutdown. After the SRI/SFS is completed, it is anticipated that EPA will issue an Amended ROD specifying the FMC Plant OU remedial action requirements.

1.3 FMC SITE DESCRIPTION AND OPERATIONAL HISTORY

1.3.1 FMC Site Description

The FMC Plant Site is located approximately 2.5 miles northwest of Pocatello, Idaho, and 1 mile southwest of the Portneuf River, a tributary of the Snake River. The FMC Plant Site is south of Highway 30, covers approximately 1,150 acres, and historically contained all of the process operations used for the production of elemental phosphorus. The Plant Site adjoins the western boundary of the Simplot Don Plant, as shown on Figure 1-1. There are an additional 212 acres owned by FMC located north of Highway 30 (excluding the 9-acre Tesco property) that are also part of the FMC OU, but which have not been identified as areas with P4 contamination. Figure 1-1 also shows where the FMC OU is located in the State of Idaho and in relationship to the municipalities of Pocatello and Chubbuck. The FMC Plant OU is on privately-owned fee land, most of which is located within the exterior boundaries of the Fort Hall Indian Reservation.

A more detailed description of the site's physical characteristics can be found in Section 2.0 of the *SRI Report*. Additional detailed information on the geology and hydrogeology of the EMF Site study area and the FMC Plant OU is presented in Sections 3.1 and 3.3, respectively, of the *EMF RI Report*, as well as Section 2.0 of the *Groundwater Current Conditions Report for the FMC Plant Operable Unit* (MWH, October 2008).

1.3.2 Historic FMC Plant Process Description

The FMC Plant Site produced elemental phosphorus (P4) from phosphate-bearing shale ore mined regionally. Figure 1-2 shows the location of process areas of the site and the remediation units (RUs) identified for performing the SRI. Ore was shipped to FMC via the Union Pacific Railroad during the summer months and stockpiled (in RU 7). The ore was crushed, screened, and formed into briquettes prior to heat treatment (known as calcining). The calcining process (located within RU 8) involved heating the ore briquettes to a sintering temperature of approximately 1,200°F to form nodules. Carbon monoxide (CO), a by-product of the phosphorus furnace reaction, was used as fuel to fire the calciners. The nodules were blended with coke and quartzite (known as silica) to make the phosphorus furnace feed. This mix of nodules, coke and silica was fed into four electric arc furnaces (located within RU 1). The furnace reaction primarily yielded gaseous P4, CO gas, slag, and ferrophos (FeP). The P4 gas was subsequently condensed to a liquid state and stored in sumps and tanks in the furnace building and phos dock prior to shipment off-site as product.

P4 will burn upon contact with air. Therefore, to prevent oxidation, the condensed phosphorus product was kept covered with water from the time it was produced through loading and transport off-site. All of the elemental phosphorus product manufacturing and handling processes were located within RU 1, with the exception of long-term phosphorus storage tanks located in RU 6.

Process water (known as phossy water) was used to isolate elemental phosphorus from contact with air and to slurry precipitator dust (a furnace by-product). Phossy water and precipitator slurry were typically managed separately in a series of surface impoundments located to the west of the elemental phosphorus furnaces. A number of these surface impoundments (Ponds 8S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18A, 8E, and 9E) were closed and capped under EPA-approved RCRA closure plans and are not subject to the SRI/SFS (designated as RU 22a). Numerous other surface impoundments were historically dewatered and/or covered. These ponds, which had ceased receiving wastes prior to termination of their Bevill exemption and thus were not subject to RCRA, are located within RU 22b. The railroad swale (designated as RU 22c) was designed as a stormwater retention area but also received phossy water (and therefore P4) from process spills in the furnace building and phos loading dock.

More detailed information regarding the ore processing, by-product handling, and waste management operations at the FMC Plant Site is provided in Sections 1.1.2 through 1.1.3 of the *EMF RI Report*.

1.3.3 Description of FMC Plant Site P4 Product and P4-Containing By-Products

The following subsections provide a brief description of P4 and other materials (precipitator solids, phossy solids, and native soil) that could be expected to be encountered along with P4 at the FMC Plant Site and thus are important in evaluating P4 treatment technologies during the SFS. It should be noted that slag and ore from the P4 manufacturing process would also expected to be encountered along with P4. A description of these materials can be found in Sections 1.3.3.1 and 1.3.3.2 of the *SRI Report*, respectively.

1.3.3.1 Description of P4

The primary product from the FMC facility was white (or yellow) phosphorus. Elemental phosphorus (P4) exists in three distinct configurations called allotropes, all with the same molecular weight, but each differing significantly from the other allotropes in physical and chemical characteristics. The chemical formula for all allotropes of elemental phosphorus is P4; however, they have different names according to their respective colors, including black, red, violet, and white (sometimes called yellow due to impurities). While some transformation of white (or yellow) P4 may have occurred at the FMC Plant Site at very insignificant rates, by far the predominant allotrope expected to be encountered on site is white (or yellow). Therefore, the SFS technology screening will be limited to white P4.

Physical & Chemical Characteristics: White P4 is a waxy solid that may be colorless, white, or yellow, and has a garlic-like odor. Table 1-2 provides a summary of some of the physical properties of P4, which shows that it is relatively insoluble in water, with a solubility of 3 mg/L at 15°C.

The primary processes for chemical transformation of P4 are oxidation and hydrolysis. In a solid phase such as in soil, P4 oxidizes spontaneously with oxygen in air to form phosphorus pentoxide (P_4O_{10}, commonly expressed as P_2O_5), which exists as a particulate at ambient conditions. Phosphorus pentoxide has a strong affinity for water and will react with water (hydrolyze), including moisture from the atmosphere, to form various phosphorus acids, primarily orthophosphoric acid (H_3PO_4). In water, dissolved P4 is oxidized by dissolved oxygen (DO) to form various forms of soluble phosphorus acids, including $H_2PO_4^-$, HPO_4^{-2}, and PO_4^{-3}. In water with other dissolved ions, and depending on environmental conditions such as pH and Eh, these acids may be further converted to a solid metal phosphate compound such as calcium phosphate. The rate of phosphorus oxidation in water is governed by the form of the phosphorus (dissolved or suspended), DO concentration, salt concentration, metal ion concentration, pH, and temperature.

Table 1-2. Physical Properties of White P4

Physical Property	Characteristic
Chemical Formula	P4
Appearance	White (or yellow) waxy solid at ambient temperatures
Boiling Point	280.5°C
Flash Point	Spontaneously combusts in air
Melting Point	44.1°C
Molecular Weight	123.89
Solubility	In water: 3 mg/L at 20°C
Vapor Pressure	0.026 mm Hg at 20°C

P4 also is hydrolyzed in water to form phosphine (PH3) and lesser amounts of phosphorus acids. PH3 is a toxic gas that has a low solubility, and thus is expected to migrate from the water to the air; the portion of phosphine that dissolves is generally oxidized to form the above-referenced forms of phosphorus acids. The rate of hydrolysis of P4 is enhanced by an increase in the pH of the water reacting with the white phosphorus (WP). (USACE, 1996)

P4-impacted soils are known (or suspected) to be present in the following areas of the FMC Plant Site:

- RU 1 – Furnace building, secondary condenser, and phos loading dock due to leaks and spills from production processes and waste management;
- RU 2 – Slag pit due to leaks and spills from production processes and waste management;

- RU 13 – Pond 8S recovery process area and metal scrap preparation area due to management of waste materials in the adjacent old pond area;
- RU 22b – Old pond area due to management and disposal of P4 containing wastes;
- RU 22c – Railroad swale, due to phossy water spills entering stormwater sewers and discharging to the stormwater retention pond; and
- Areas containing underground piping or sewer lines that carried phossy water, precipitator slurry, or CO gas, and therefore could contain P4 (RUs 1, 2, 3, 8, 12, 13, 22b, and 24) which may have P4 remaining in pipes or which may have leaked from pipes.

P4-impacted groundwater has been identified immediately downgradient (flowing to the northeast) of RUs 1 and 2. P4 in the capillary fringe soils immediately above groundwater have been identified in RUs 3 and 7, associated with this P4-impacted groundwater.

Section 1.3.4 provides a description of each of these areas, including the types of materials to be encountered along with the P4, particle sizing, P4 concentrations, and depth of P4 contamination. The physical setting in which the P4 is found and the nature of the P4 are important factors in screening and evaluating potential remedial options.

1.3.3.2 Description of Precipitator Solids

Precipitator solids (otherwise referred to as precipitator slurry, precipitator dust, and/or fluid bed dryer slurry/prills) were produced in the electrostatic precipitators immediately downstream of the phosphorus furnaces. The precipitator solids consisted of furnace feed dust and condensed constituents that had boiled off in the high temperatures of the furnace (including metals, radionuclides, and P4). Prior to 1955 precipitator solids were handled dry. After 1955, a slurry system was installed for all the precipitators with the resulting slurry being pumped to a series of ponds located in RU 22b. When possible (e.g., phosphorus content was not too high), precipitator slurry was allowed to air dry in these ponds. Dried precipitator slurry (precipitator solids) was reclaimed from these ponds and sold as a fertilizer additive due to its high zinc content.

Precipitator dust contained in any of the historical ponds is assumed to have some level of P4 remaining in the sediment matrix at concentrations ranging from 0 ppm to 10,000 ppm. However, it is important to note for the SFS technology screening that addition of precipitator slurry to historical ponds may have locally concentrated P4 to much higher levels (e.g., liquid P4 was known to have accumulated at the discharge area of piping into the ponds, resulting in a large frozen mass of highly concentrated [50% or higher] P4).

<u>Physical, Radiological and Chemical Characteristics:</u> Precipitator solids are typically described as “fine-grained, dark-gray-to-black material.” While the particle size of precipitator dust is relatively uniform, cover materials such as slag and ore placed on historical ponds certainly would impact particle size distribution of materials in these ponds.

A summary of radiological sampling results for precipitator solids is presented in Table 1-3 of the *SRI Report* and these activities are also presented in Table F-1 of the *RI Update Memo*. Elevated levels of lead-210 and polonium-210 are associated with precipitator solids (labeled "Precipitator Slurry/Phossy Wastes" in Table 1-3 of the *SRI Report*). In addition, precipitator solids were sampled as part of the SRI fill characterization study and analyzed for gross alpha, gross beta, radium-226, uranium-238, potassium-40, lead-210, and polonium-210. The radionuclide sample results from the SRI are discussed in Section 4.27 of the *SRI Report*.

Table 1-4 of the *SRI Report* presents total metals and fluoride concentrations in historical precipitator solids samples. In addition, precipitator solids were sampled as part of the SRI fill characterization study and analyzed for fluoride and metals. The fluoride and metal sample results from the SRI are presented in Section 4.27 of the *SRI Report*.

In addition to ponds in RU 22b, precipitator solids were known to be present (or have been identified through sampling) in the following areas:

- RU 1 – Precipitator dust and slurry was generated within the furnace building.
- RU 2 – Releases of precipitator slurry were at times washed from the furnace building into the slag pit.
- RU 10 – During the SRI, solids containing precipitator slurry were identified in the sediment in the non-contact water cooling pond. These solids were likely from spills of precipitator slurry within the furnace building that became co-mingled with non-contact cooling water.
- RU 12 – During the RI, solids identified as precipitator solids were identified within the western edge of RU 12. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids may have been stockpiled or spilled in this area during precipitator dust recovery.
- RU 13 – During the SRI, solids containing precipitator solids (identified as a red fill) were identified within RU 13. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids (or soils impacted by pond leaching) may have been stockpiled (or used as fill in this area.
- Areas containing underground piping or sewer lines that carried precipitator slurry (and therefore could contain P4) are located in RUs 1, 2, 12, 13, 22b, and 24.

1.3.3.3 Description of Phossy Solids

Phossy solids, otherwise referred to as phossy water solids, oxidized phossy solids, and/or phossy slurry, were produced throughout the phosphorus manufacturing process and were typically solids (consisting of ore dust, coke, dust, silica dust, slag dust and/or precipitator dust) containing phosphorus within a phossy water stream. The phossy solids accumulated within the water stream as a result of contact with phosphorus-containing process streams (e.g., phosphorus product and phosphorus sludge). These various phossy water streams were accumulated within

sumps/drains/tanks and pumped to slurry ponds located to the west of the furnace building (in RU 22b), where the phossy solids were allowed to settle and accumulate. These ponds were maintained with a water cover to prevent oxidation of phosphorus with air. Early phossy water ponds, i.e., those that ceased operation before RCRA management requirements became applicable, were eventually "closed" by dewatering and being covered with other fill materials such as precipitator dust slag, and/or native soils. These pre-RCRA historic ponds are located in RU 22b.

Phossy solids contained in any of the historical ponds or railroad swale are assumed to have some level of P4 remaining in the sediment matrix, at concentrations ranging from 0 ppm to 10,000 ppm. However, it is important to note for the SFS technology screening that addition of phossy solids to historical ponds may have concentrated P4 to much higher levels. For example, liquid P4 was known to have accumulated at the discharge area of piping into the ponds, resulting in a large frozen mass of highly concentrated (50% or higher) P4.

Physical, Radiological and Chemical Characteristics: Phossy solids that were allowed to dry typically resulted in oxidation of the phosphorus, leaving gray to dark-gray or black sediments. However, the appearance of phossy solids can vary depending on the other types of solids with which they are found (i.e., ore, coke, slag, silica or precipitator dust). While the particle size of phossy solids is relatively uniform, cover materials such as slag and ore certainly would impact the particle size distribution of materials in historical ponds.

A summary of radiological sampling results for phossy solids is presented in Table 1-3 of the *SRI Report*. These activities are also presented in Table F-1 of the *RI Update Memo*. An additional phossy solids sample was collected as part of the SRI fill characterization study and analyzed for gross alpha, gross beta, radium-226, uranium-238, potassium-40, lead-210, and polonium-210. All the SRI radionuclide sample results are discussed by RU in Section 4.27 of the *SRI Report*.

Table 1-4 of the *SRI Report* presents total metals and fluoride concentrations in historical phossy solid samples. In addition, a phossy solids sample was collected as part of the SRI fill characterization study and analyzed for fluoride and metals. The fluoride and metal sample results from the SRI are presented in Section 4.27 of the *SRI Report*.

In addition to ponds in RU 22b, phossy water and phossy solids were known to be present, or have been identified through sampling, in the following areas:

- RU 1 - Most phossy water was generated within the furnace building, phos dock and secondary condenser where P4 was produced, stored, and recovered.

- RU 2 – Releases of phossy water were at times washed from the furnace building into the slag pit.

- RU 12 – During the RI, solids identified as precipitator solids were identified within the western edge of RU 12. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids may have been stockpiled or spilled in this area during precipitator dust recovery.

- RU 13 – During the SRI, solids containing precipitator solids (identified as a red fill) were identified within RU 13. Although there are no historical records to indicate that a surface impoundment ever existed in this area, pond solids (or soils impacted by pond leaching) may have been stockpiled or used as fill in this area.

- RU 22c - Phossy water spills to the surface in the furnace building or phos dock were often captured in the storm sewer system, which discharged to the railroad swale (stormwater retention pond).

- Areas containing underground piping or sewer lines that carried phossy water (and therefore could contain P4) are located in RUs 1, 2, 3, 12, 13, 22b, and 24.

1.3.3.4 Description of Native Soils

Surface soils at the FMC Plant OU originated from deposition by fluvial erosion and deposition (alluvium), collection at the base of slopes (colluvium), weathering in place (residuum), and deposition by wind (loess). As described in Section 1.2 of the *EMF RI Report* and in Section 2.2.2 from the *FS Report*, the area where the FMC Plant OU is located is underlain to some depth by soils consisting of calcareous silts and clays (loess). These silts and clays have an average pH greater than 8 and, because of their calcareous nature, a high buffering capacity. The high pH will act to neutralize acidic materials, precipitate cations that form carbonate solutions, and provide for numerous cation exchange opportunities for trace elements. The silts are of greatest thickness in the western and central portions of the FMC Plant Site and extend to the south beyond the FMC Plant OU boundary (BEI, 1997).

The stratigraphy of the FMC Plant OU generally can be described as discontinuous layers of unconsolidated sediments deposited on an erosional surface that was incised in volcanic bedrock. The sedimentary units immediately above the bedrock are gravels derived from volcanic rocks. The stratigraphy at the FMC Plant OU includes, in ascending order, volcanic bedrock units (rhyolite, tuff, and some basalt), coarse volcanic and quartzitic gravels, fine-grained sediments of the American Falls Lake Bed, Michaud gravels, Aberdeen alluvial terrace deposits (locally) and loess deposits of calcareous silts and clays. Loess is present at both higher elevations and lower elevations of the site in varying thicknesses. Loess deposits are much thicker in portions of drainages where they have been reworked and redeposited.

1.3.4 Description of Areas (RUs) Where P4-Impacted Soils Are Expected

Because of the differing process operations within the FMC Plant Site that managed P4 product and P4-containing waste, different areas of the site that are known or suspected of having P4-impacted soils have varying physical settings in which P4 is or may be encountered in the subsurface. Deposited P4 is typically associated with varying amounts of slag, ore, precipitator solids, phossy solids, and native soils. In order to effectively screen and evaluate P4 treatment technologies and, as discussed in Section 2.0, the ancillary processes necessary to implement a treatment technology, it is critical to understand the following physical properties in each differing area of the site:

- Relative P4 concentrations and the variability of P4 concentrations across the area;
- Depth of P4 deposition;
- Total volume of P4 and impacted fill that must be handled and processed;
- Particle size distribution, not only of the frozen P4 particles, but also of other fill materials and soils associated with the P4-impacted matrix; and
- Other fill materials (and associated COCs) included in the P4-impacted matrix that must also be treated or handled.

Table 1-3 provides a summary of these physical characteristics for the areas of P4-impacted soils. These physical characteristics for each of the areas of P4-impacted soils are further described in the following subsections.

1.3.4.1 Furnace Building, Phos Dock & Secondary Condenser (RU 1) and Slag Pit (RU 2)

RU Description: RU 1 is 4.1 acres in size and encompasses the locations of the former furnace building, secondary condenser, and phos dock. These were the primary P4 product production, storage, and handling areas within the FMC Plant Site. The furnace building contained electric arc furnaces, primary condensers, P4 sumps, and various tanks. The secondary condenser was downstream of the furnaces and provided final recovery of P4 product, collecting that in a single sump. P4 from the furnace sumps and the secondary condenser sump was pumped to the phos dock for storage and loading onto rail cars for shipment. Because of the pyrophoric nature of the P4, the P4 product was contained within a closed system, consisting of piping, pumps and tanks, and was always covered with water to prevent the P4 from contacting air. Water that came into contact with P4 was known as phossy water and typically contained small particles of P4, ore dust, coke dust, silica dust, and P4 reaction products. This phossy water was pumped via underground and aboveground piping to ponds in RU 22b.

Furnace offgas, containing primarily CO and P4 gases, passed through an electrostatic precipitator in which particulate was removed to clean the offgas stream. The dust collected in the electrostatic precipitator, known as precipitator dust, was then slurried with recycled water and pumped via underground and aboveground piping to ponds in RU 22b and RU22a (RCRA Ponds).

RU 2 is 3.7 acres in size and encompasses the former slag pit located immediately south of the furnace building (RU 1). It is an area where molten slag from the furnaces was poured, cooled, broken, and loaded onto slag haul trucks to be placed on the slag pile (RU 19). In 1999-2000, FMC converted to slag ladling, where the molten slag was poured from the furnaces into ladles. The ladles were truck mounted, allowing for the molten slag to be transported to the slag pile where it was poured down the face of the slag pile and allowed to cool and solidify. Prior to implementing slag ladling, the soils beneath RUs 1 and 2 (down to groundwater) were heated by the molten and cooling slag to above the 44°C melting point of P4.

The heated column of soil located beneath the furnace building and slag pit respectively at RUs 1 and 2 would allow the P4 from surface and subsurface spills, such as spills or releases from product sumps, underground piping, and slag pit catch basins, to remain as a liquid and thus move downward to groundwater (to a depth of approximately 85 feet). The phos dock and secondary condenser are positioned well outside the 44°C isotherm; thus, there is limited potential for migration of P4 downward to the groundwater in these areas.

P4 therefore likely exists in soils and fill materials to a depth of 10 feet throughout RUs 1 and 2 at concentrations varying from 0 to 50%, with the highest concentrations being immediately under P4 product sumps. Within the 44°C isotherm, P4 likely exists throughout the soil column to groundwater. As liquid P4 likely filled the void spaces between soil particles in the vadose zone, concentrations up to 30% may be possible.

Fill Materials: As summarized on Table 4-2 of the *SRI Report*, the surface of RU 1 and RU 2 is made of up of slag, concrete foundations, asphalt with slag aggregate, and silica. The subsurface fill materials around the perimeters of RUs 1 and 2 consist primarily of slag, concrete foundations, and reworked native soils and slag. Although not visually identified, process knowledge has identified precipitator solids as an incidental fill material in RUs 1 and 2. The native soil interface around the perimeters of the RUs ranges between 1.5 and 20 feet bgs. With a predominance of slag on the surface, particle size distribution down to 20 feet bgs would range from very fine to plus 6-inch. The concrete slabs within RU 1 range from 2 feet to 10 feet in thickness and are highly steel reinforced.

Below 20 feet bgs and within the 44°C isotherm, the P4 is likely to be within native soils, consisting of gravelly silts and sands in the upper three to nine feet, followed by 20 to 30 feet of silt to sandy silt, 40 to 50 feet of coarse sands, gravels, and cobbles, and finally 10 feet of silts and sandy silts at the capillary fringe.

As discussed in Section 4.2 of the *SRI Report*, groundwater is encountered at a typical depth of 85 feet bgs. P4 was encountered (as evidenced by slight smoking) at the capillary fringe in 2 borings in RU 3 and at 1 boring in RU 7, both immediately downgradient to the northeast of RU 1. Based upon the 2-foot split spoon interval that was sampled and observed, the P4 was limited to a 2-foot interval immediately above the groundwater. Based upon the amount of smoking observed in the capillary fringe sample, it is estimated that the P4 concentration was at least 1,000 ppm but well below 10,000 ppm.

As discussed in Section 4.2.4 of the *SRI Report*, the P4 estimated to be present combined within RUs 1 and 2 is 580 to 5,470 tons. RUs 1 and 2 contain total estimated fill volumes of 56,580 yd^3 and 20,485 yd^3 respectively.

Summary of Pertinent SFS Information for RUs 1 and 2:

- P4 concentrations vary from 0 to 50% across the RUs at depths down to 10 feet, 0 to 30% in soils down to the capillary fringe at 80 feet bgs (within the 44°C isotherm), and 1,000 to less than 10,000 ppm within the 2-foot capillary fringe encountered at about 83 feet bgs;

- Total estimated mass of P4 is 580 to 5,470 tons and total estimated volume of fill is 77,065 yd^3;

- Particle size distribution for fill materials would range from minus ¼-inch to plus 6-inch, (with crushed slag amassing to form monolithic particles several feet in diameter in some areas) with a similar range for native soils; and

- Other fill materials include slag, concrete, asphalt, silica, phossy solids, precipitator solids, and underground piping (see Section 1.3.4.4).

1.3.4.2 Historical Surface Impoundment Area (RUs 13 and 22b)

RU Description: RU 13 is 3.6 acres in size and is located in the south-central portion of the FMC Plant Site, as shown on Figure 1-2. It is immediately southwest of RU 12 and is adjacent to several old ponds. RU 13 is north of a portion of RU 22b (old phossy water ponds). Because RUs 13 and 22b share a common boundary and have similar fill materials, this report evaluates them together. Although RU 13 was never documented to have been used directly in the P4 production process operation, in the mid-1980s a process was developed, built, and tested on the northern side of Pond 8S to recover P4 from Pond 8S. This process (the Pond 8S recovery process) was located within the RU 13 boundaries. The Pond 8S recovery process was shut down, closed and removed in 1993. Pond solids may have been stockpiled or used in RU 13 as fill material prior to construction of the Pond 8S recovery process.

RU 22b is 37.7 acres in size and consists of four separate parcels in the western portion of the FMC Plant Site as shown on Figure 1-2. As described above, waste streams that contained P4 (i.e., phossy water and precipitator slurry) were slurried and pumped to a series of ponds at RU 22b. The hydraulic head at the old ponds was removed through solar evaporation.

In 1954, the initial ponds in RU 22b were created and began receiving phossy water. In 1955, a slurry system was installed for all the precipitators with the resulting slurry similarly being pumped to ponds within RU 22b. When possible (e.g., phosphorus content was not too high), precipitator slurry was allowed to air dry in these ponds. Dried precipitator slurry (precipitator solids) was reclaimed from these ponds and sold as a fertilizer additive due to its high zinc content. All of the ponds located in RU 22b (with the exception of Pond 10S) were closed during a period from 1972 through 1976 by being covered with various materials, including native soil, dried precipitator dust and prills, ore, and slag.

Precipitator solids and phossy solids contained in any of the historical ponds is assumed to have P4 remaining in the sediment matrix at concentrations ranging from 0 ppm to 10,000 ppm. However, it is important to note for the SFS technology screening that addition of precipitator slurry to historical ponds may have concentrated P4 to much higher levels, for example though the accumulation of liquid P4 at the piping discharge area as the heated phossy water/precipitator slurry stream discharged into the surface impoundment. P4 in the liquid phase tended to immediately freeze upon entering the surface impoundment and create a large frozen mass of highly concentrated P4 (50% or higher). During operation of the ponds, the piping discharge point was periodically moved to prevent “islands” of sediments from extending above the water

line. Therefore, areas of highly concentrated P4 associated with the pipe discharge are variably distributed throughout the pond sediments.

Fill Materials: As summarized on Table 4-2 of the *SRI Report*, the fill materials within RUs 13 and 22b consist of slag, concrete foundations, asphalt with slag aggregate, precipitator solids, phossy solids, ferrophos, underground piping and reworked native soils (i.e., native soils that have been mechanically mixed with other fill materials). Fill depth within RU 13 ranges from 1 to 25 feet. Fill depth within RU 22b ranges from 0 to 44 feet.

As discussed in Section 4.13.4 of the *SRI Report*, the mass range of P4 estimated for RU 13 is 25 to 60 tons. The total volume of all fill materials at RU 13 is 66,630 yd^3. As discussed in Section 4.18.4 of the SRI Report, the mass range of P4 estimated for RU 22b is 4,440 to 10,800 tons. The total volume of all fill materials for RU 22b is 595,820 yd^3.

Summary of Pertinent SFS Information for RUs 13 and 22b:

- P4 concentrations vary from 0 to 50% across the RUs;
- Depth of P4 contamination extends to 44 feet bgs (maximum depth of former ponds / fill material);
- Total estimated mass of P4 is 4,465 to 10,860 tons and total estimated volume of fill is 662,450 yd^3;
- Particle size distribution for fill materials would range from minus ¼-inch to plus 6-inch , (with crushed slag often becoming compacted in-place to form monolithic layers up to several feet in thickness in some areas as observed during the SRI trenching conducted at RU22c); and
- Other fill materials include slag, concrete, asphalt, ore materials, phossy solids, precipitator solids, ferrophos, and underground piping (see Section 1.3.4.4).

1.3.4.3 Railroad Swale (RU 22c)

RU Description: RU 22c is 2.4 acres in size and is located to the north of the P4 production areas along the northeastern boundary of the FMC Plant Site, as shown on Figure 1-2. The railroad swale was designed as a stormwater retention area. It received stormwater from the underground storm sewer piping within the plant production area. However, phossy water spills and releases from the furnace building and phos dock also discharged to the railroad swale, either through the underground storm sewer piping or by over-surface flows. As a result, the railroad swale received not only stormwater but also P4 and phossy solids. Because the railroad swale ran parallel to the ore stockpile, ore dust was also likely to have blown into the swale. In the mid-1980s the railroad swale was dug out to a depth of 10 to 20 feet and backfilled with slag. It was partially lined in 1993 to reduce infiltration of water into the subsurface.

Although the railroad swale received phossy water (and associated P4), this discharge was at ambient temperatures. Therefore, the P4 deposition was different than in the ponds within RU

22b, i.e., there is no evidence of concentrated areas of P4 in the railroad swale. During the SRI, one trench across the railroad swale was found to contain P4, as evidenced by slight smoking. It is presumed, based upon the SRI sampling and process knowledge that P4 concentrations in the sediment matrix within the railroad swale are fairly consistent and range from 0 ppm to less than 10,000 ppm.

Fill Materials: As summarized on Table 4-2 of the *SRI Report*, the fill materials within RU 22c contain slag (presumed to minus 2-inch be crushed slag), phossy solids, and ore. Fill depth within RU 22c ranges from 5 to 20 feet (based upon historical knowledge and SRI findings).

As discussed in Section 4.19.4 of the *SRI Report*, the mass range of P4 estimated for RU 22c is 4 to 10 tons. The estimated total volume of all fill materials for RU 22c is 40,607 yd^3.

Summary of Pertinent SFS Information for RU 22c:

- P4 concentrations vary from 0 to less that 10,000;
- Depth of P4 contamination extends to 20 feet bgs;
- Total mass of P4 is 4 to 10 tons and total volume of fill is 40,607 yd^3;
- Particle size distribution for fill materials would range from minus ¼-inch to 2-inch(with crushed slag amassing to form monolithic particles several feet in diameter in some areas); and
- Other fill materials include slag, phossy solids, and ore.

1.3.4.4 Areas with Underground Piping Suspected of Containing P4

There are a number of RUs that contain underground piping that were used to carry phossy water, precipitator slurry or CO gas from the furnace building, slag pit and phos dock to other areas of the plant. Underground storm water piping that at times likely conveyed phossy water also is present in RUs 1, 3, and 24. All this underground piping was left in place during decommissioning of the plant and, while it was allowed to gravity drain, it was not cleaned in place. As such, the underground piping may contain P4. RUs where these underground piping or stormwater lines that exist are RUs 1, 2, 3, 8, 12, 13, 22b, and 24. Underground piping was constructed of mild steel, although the storm water piping in RUs 1 and 3 was constructed of concrete. While the underground piping was likely placed at least 3 to 5 feet below grade at the time of installation to protect against freezing, additional fill may have been placed on top of older piping such that some piping may be up to 10 to 15 feet below the current surface.

In contrast to the P4 processes in RU 1, the old underground pipelines that transported precipitator slurry or phossy water to the phossy ponds in RU 22b were not heated. The old pipelines were placed underground to prevent the wastewater in the pipelines from freezing during winter conditions. The P4 wastewater from RU 1 was at typical operating temperatures (60 to 66 C) when pumped into the pipelines. The temperature of the wastewater in the old

underground pipelines would not have added a significant heat load, in terms of increased temperature, to the surrounding soil beyond a few feet from these lines.

Soil temperatures are not elevated above a natural range of subsoil temperatures (approximately 12 to 17 C) in the subsurface beneath the precipitator slurry and phossy water pipelines, excluding those segments of pipelines in RUs 1 and 2 that were within the 44° C isotherm associated with the slag pit. In the areas outside the 44° C isotherm in RUs 1 and 2, a release of P4 to the subsurface (e.g., pipeline leak) would freeze fairly rapidly and be immobilized in an area near the point of release. Migration of P4 beyond a few feet from the lines would have been limited to dissolved P4 at a concentration below the solubility limit of P4.

One underground CO line remains within RU 8, consisting of the former CO feed line to the calciners. While this CO line may contain a small quantity of fairly pure P4, the CO line most likely did not leak because a leaking CO line would have been detected immediately.

Underground storm water lines in RUs 1, 3, and 24 did carry phossy water to the railroad swale. There is potentially some P4 remaining in the bottom of these storm sewer lines, although since these streams were managed at ambient temperatures, P4 would likely not have accumulated. Leaks may have occurred at the cement piping joints, although migration of P4 beyond a few feet would not be expected.

P4 concentrations within the underground piping may range from 1% to 100%. As discussed in Section 4.26.4 of the *SRI Report*, the mass range of P4 estimated collectively within the remaining phossy water and precipitator slurry underground pipelines is between 2.8 and 28 tons. The P4 estimated within the single remaining underground CO line is between 0.2 and 1.8 tons. The underground storm water piping is estimated to contain between 0.13 and 0.6 tons of P4. These P4 mass estimates do not include potential leakage or loss at pipeline cleanouts (from maintenance) that may have occurred but is not quantifiable.

<u>Summary of Pertinent SFS Information for Underground Piping:</u>

- P4 concentrations vary from 1% to 100% throughout the underground piping;
- Depth of P4 contamination is estimated to be no deeper than 15 feet below the current surface;
- Total volume of P4 is estimated to be between 3.13 to 30.4 tons collectively for all the underground piping;
- Other fill material in and around the underground piping includes slag, phossy solids, precipitator solids, ore, and native soils.

1.4 REPORT ORGANIZATION

The remainder of this document is organized as follows:

Section 2.0 – Ancillary P4 Technology Processes - primarily discusses the processes that are required on the upstream and downstream sides of the treatment train that have to be considered when implementing these active technologies at full scale.

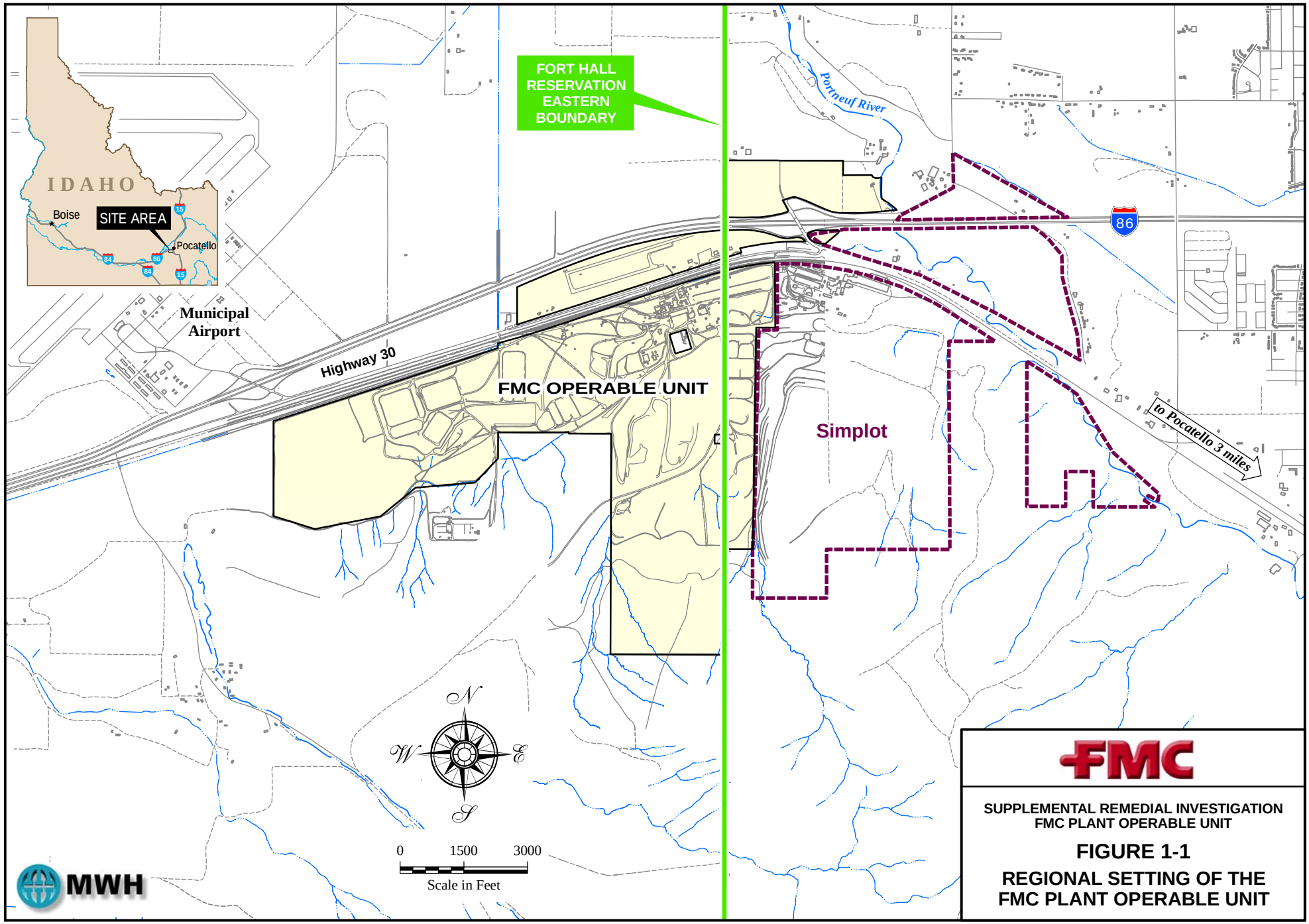
Section 3.0 –Elemental Phosphorus Treatment Technologies for Soil – discusses each technology identified for potential applicability to P4-impacted soils.

Section 4.0 – Elemental Phosphorus Treatment Technologies for Groundwater – discusses each technology identified for potential applicability to P4-impacted groundwater.

Section 5.0 – Findings - reviews the findings reached in the *2003 Treatment Technologies Report* and, considering the more recent information included in this summary report and updates those findings.

Section 6.0 - Reference List

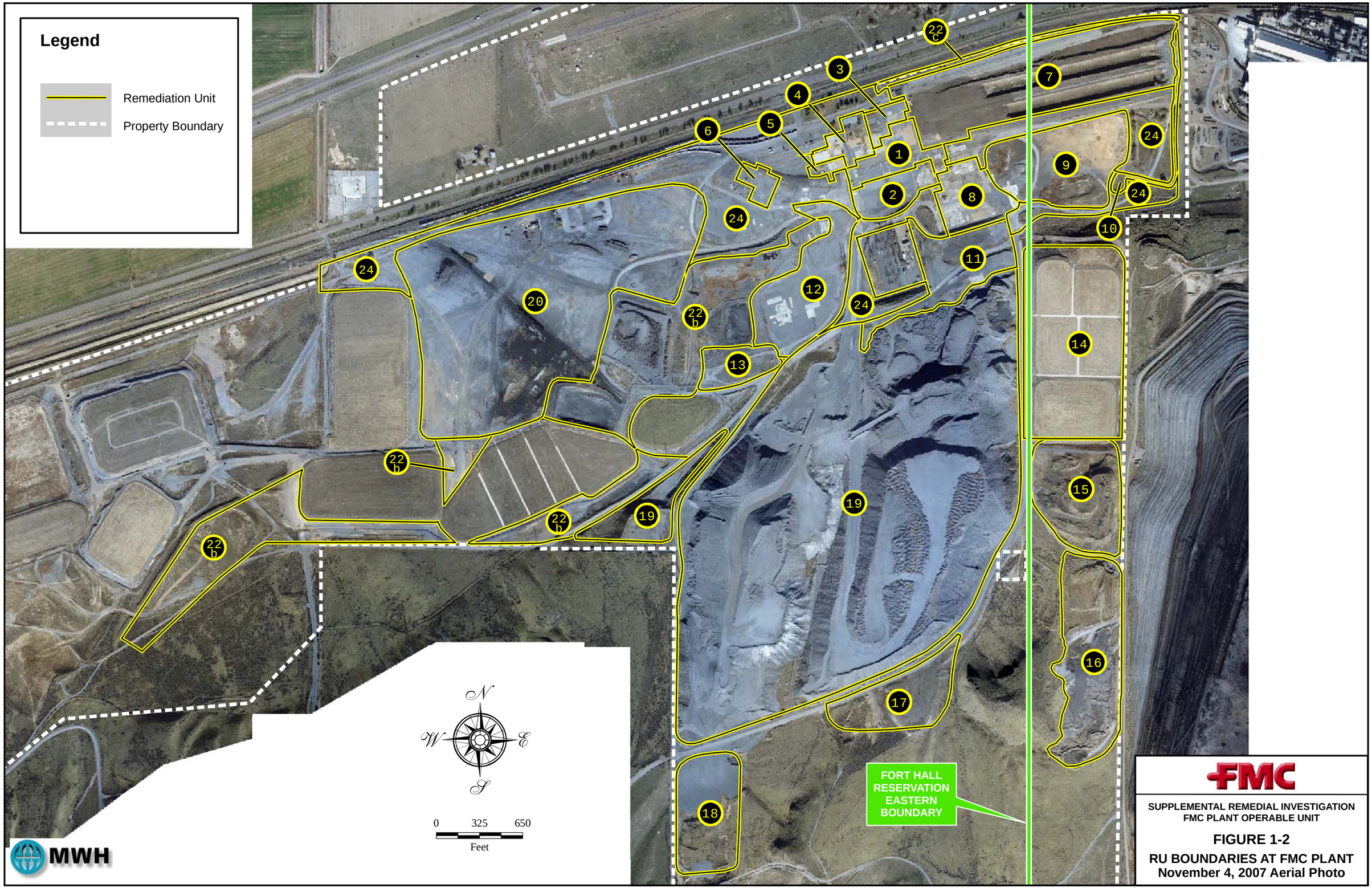
FILE *Fig 1-01 Regional Setting_508.mxd* *5/03/08*



SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-1

REGIONAL SETTING OF THE FMC PLANT OPERABLE UNIT



FILE Fig 1-02_RU Bndries at FMC Plant_208.mxd 4/14/08

FMC

SUPPLEMENTAL REMEDIAL INVESTIGATION
FMC PLANT OPERABLE UNIT

FIGURE 1-2

RU BOUNDARIES AT FMC PLANT
November 4, 2007 Aerial Photo

TABLE 1-1

SUMMARY OF P4 SOIL / SOLID WASTE REMEDIES– COMMERCIAL AND MILITARY SITES

COMMERCIAL P4 PRODUCT MANUFACTURING, HANDLING, and/or DISPOSAL SITES	
Name and Location	**P4 soil/solid waste Remedy and oversight agency**
Rhodia (fka Stauffer Chemical Company), former Elemental Phosphorus Production Plant, Silver Bow, Montana	In the RCRA corrective action process, CA not yet determined. [EPA]
Monsanto Company, former Elemental Phosphorus Production Plant, Columbia, Tennessee	Cap (design information not readily accessible) over areas contaminated with elemental phosphorus. [State]
Monsanto Company (aka P4 Production LLC), Elemental Phosphorus Production Plant, Soda Springs, Idaho	Cap (design information not readily accessible) over former ponds; operating facility subject to further remedial actions at closure. [EPA]
Tennessee Valley Authority, former Elemental Phosphorus Production Plant, Muscle Shoals, Alabama	Cap (1 foot of limestone and 6 inches of concrete) over buried sludges. [State]
Stauffer Chemical Company, former Elemental Phosphorus Production Plant, Tarpon Springs, Florida	Cap (design information not readily accessible) over unlined ponds after in situ stabilization plans abandoned due to fires and uncontrolled reactions. Groundwater remedy includes cut off wall for shallow aquifer. [EPA]
Stauffer Chemical Company (Rhone Poulenc), former Elemental Phosphorus Production Plant, Mt. Pleasant, Tennessee	Cap (design information not readily accessible) and deed restrictions. [State]
Exxon Mobile, ElectroPhos Division, former Phosphate Production Plant, Mulberry, Florida	Cap (HDPE) over former ponds. Groundwater remedy also included low permeability soil-bentonite slurry wall around the pond perimeter. [State]
Glenn Springs Holding Company (aka Hooker Chemical Co and Occidental Chemical Co), former Elemental Phosphorus Production Plant, Columbia, Tennessee[1]	Cap (design information not readily accessible) proposed as the final remedy for pond closure; formerly used alkali (i.e., lime) treatment on waste streams from P4 recovery process in active ponds. [State]
Agrifos Nichols Plant, former Phosphate Production Plant, Nichols, Florida	Cap (earthen) 2 feet of soil over closed ponds; drummed and buried P4 solids. [State]

TABLE 1-1

SUMMARY OF P4 SOIL / SOLID WASTE REMEDIES– COMMERCIAL AND MILITARY SITES

Albright and Wilson (aka ERCO), former Elemental Phosphorus Production Plant, Long Harbor, Newfoundland, Canada	Cap (design information not readily accessible) over "Mud holes" after recoverable P4 removed. [Environment Canada]
Union Pacific Railroad Company - Fairfield (aka Suisun Marsh Phosphorus Railcar Derailment), Fairfield, CA[1]	Cap (concrete) over 2 buried rail car(s). [State]
Southern Industrial Machine Company (SIMCO), former phosphorus railcar cleaning facility, Tennessee[1]	Cap (design information not readily accessible) over former ponds. [Private party voluntary]
FMC, former Phosphate Production Plant, Newark, California[1]	Cap (concrete) over closed underground P4 concrete storage tank and impacted soils. [State]
MILITARY FACILITIES WITH P4 MUNITIONS/WASTES	
Name and Location	**Remedies or Partial Remedies**
Defense Depot Ogden Utah (DDOU), former munitions disposal area, Ogden, Utah[1]	Thermal desorption [State and EPA]
Eagle River Flats, primary munitions impact area, Fort Richardson Army Base, Alaska	Sublimation and oxidization of P4 (max concentrations approximately 3,000 ppm) after draining ponds [EPA]
Crane Army Ammunition Activity, munitions storage site, Crane, Indiana	Incineration of WP in unexploded ordnance, capture and production of phosphoric acid [EPA]

[1] Phosphorus sites not reviewed in EPA's *2003 Treatment Technologies Report*.

TABLE 1-3

P4 DISTRIBUTION AND ASSOCIATED DETAILS IN REMEDIATION UNITS
FMC PLANT OU

RU Designation	Range of P4 Concentrations	Depth of P4 Contamination (bgs)	Fill Particle Size[1]	Estimated Quantity of P4 (tons)[2]	Total Fill (yd^3)	Other COCs
RUs 1/2	0-50% 0-30% 1,000-10,000 ppm	0-10 ft 10-80 ft 83-85 ft	<1/4"- >6"	580-5,470	77,065	Rads, metals
RUs 13/22b	0-50%	0-44 ft	<1/4"- >6"	4,465-10,860	662,450	Rads, metals
RU 22C	0-10,000 ppm	0-20 ft	<1/4"- >2"	4-10	40,607	Rads, metals
Piping in RUs 1, 2, 3, 8, 12, 13, 22b, 24	0-100%	3-15 ft	unk	3-30	unk	Rads, metals

[1] Does not consider foundations and piping

[2] Estimated minimum and maximum quantity of P4 in soils/sludges in tons

Section 2.0 P4 Technology Ancillary Process Options and Issues

2.1 INTRODUCTION

Several treatment technologies have been attempted, primarily in the laboratory, for remediation of soils and fill materials containing elemental phosphorus. These in-situ and ex-situ P4 treatment processes are discussed in Section 3.0. Ex-situ technologies require the excavation of soil and solids followed by an above-ground treatment process. Implementing ex-situ technologies requires additional process steps such as excavation and storage that are not required for in-situ technologies. Ex-situ technologies also require that a portion of the site be used and potentially impacted to implement the technology, including possible staging areas for treatment equipment and soil stockpiles. In-situ technologies require the addition (e.g., injection) of physical or chemical agents directly into the soil without removal of the soil. In-situ technologies would need to consider the effects of the treatment on the physical and chemical characteristics of the subsurface, including groundwater. Some technologies, such as stabilization and solidification, have been evaluated for both in-situ and ex-situ treatment.

Prior to any possible ex-situ treatment or disposal (on-site or offsite), P4-contaminated soils/sludges would require removal through conventional excavation or wet dredging so that the wastes could be transported for treatment. The material handling issues associated with excavation of soils containing P4 at concentrations over 1,000 ppm and preparation of those soils for treatment are documented as the most difficult issues to overcome with active treatment of P4 wastes. Various P4 handling processes that would be ancillary, but critically important to the success of the treatment technology, are introduced and discussed below. The P4 handling issues are the first step in what would be a difficult and potentially dangerous P4 treatment process train. Additional engineering and safety issues associated with all the treatment options for P4-contaminated wastes, i.e., common to both in-situ and ex-situ treatment options, are also discussed in this section.

2.2 ANCILLARY P4 TREATMENT PROCESSES AND ISSUES

It is important to recognize that a given treatment technology may require several ancillary process steps in order to be implemented. These ancillary process steps are common to many of the treatment technologies and are discussed in this section. Ancillary process steps that would be integral to the treatment process must be considered when screening/evaluating potential technologies using the standard EPA decision criteria of implementability, effectiveness, and cost.

Common ancillary P4 treatment processes for soils/fill materials include the following:

- Material/waste handling issues:
    - P4 excavation processes necessary to get P4-impacted materials to an ex-situ treatment process;
    - P4-impacted material transportation to the ex-situ treatment process, and temporary storage of such material near the treatment process to provide surge capacity;
- Treatment process feedstock preparation:
    - Sizing, such as crushing and screening, of the material to provide a consistent feed particle size to the ex-situ treatment process;
    - Blending with other extracted streams or inert materials of the feed to provide consistent P4 content to the ex-situ treatment process; and
- Management of treatment residues
    - Treatment of wastewater, further treatment and disposal of solid residues, and collection and treatment of process off-gases.

There are several engineering and safety challenges, unique to P4 waste handling and treatment, that must be identified and addressed in the overall technology treatment evaluation using the fundamental decision criteria of implementability, effectiveness, and cost. These include the following:

- Site worker health and safety;
- Public health and safety; and
- Potential environmental impacts.

2.2.1 P4-Impacted Soil Excavation and Treatment Feed Preparation

Excavation by conventional or hydraulic means would be necessary for any ex-situ treatment technology for remediation of P4-impacted soils. The following subsections discuss dry and wet excavation options and the engineering challenges associated with these ancillary process options.

2.2.1.1 Conventional Excavation

Excavating soils containing P4 greater than 1,000 to 10,000 ppm with conventional earthworking equipment (e.g., trackhoes, excavators, clam shells, draglines, etc), presents a unique challenge

in that once P4-impacted soils are exposed to ambient air, P4 oxidation (burning) is likely to occur. Without extreme measures such as covering the excavation site with an impermeable structure or keeping the area flooded with water, remediation workers and receptors located downwind the excavation could be exposed to aerosols associated with P4 combustion. In addition to the principal combustion product P_4O_{10} and its hydrolysis product orthophosphoric acid, the vapor cloud may also contain trace quantities of unreacted P4 (Van Voris et al. 1987) and/or a complex mixture of suboxides of P4 including phosphorus trioxide (P_4O_6), which reacts with water to form phosphine (PH_3) at low oxygen levels (Spanggord 1985). Any conventional excavation option would need to meet the criteria of being implementable and effective at both removing the P4-containing soil and preventing worker and off-site exposures to P4 reaction products. The most immediate threat from conventional excavation would be the thermal burning of P4. Such burning would pose a significant threat to remedial workers and equipment. Extreme caution, including extraordinary procedures and PPE, would be required to prevent severe injury to remediation workers and damage to equipment. Similar to the point made above, any conventional excavation option would need to meet the criteria of being implementable and effective at both removing the P4-containing soil and preventing risks to workers and equipment from direct exposure to burning P4. Sufficient accounting also would need to be done regarding the capital and O&M costs associated with designing and operating a conventional excavation process that would prevent such exposures and resulting worker and off-site risks.

While performing conventional excavation, significant quantities of water would be needed to minimize the exposure of P4 to ambient air. The water would be used to saturate the excavation site and for equipment cleaning. Use of water in the excavation would provide hydraulic head on existing contaminants, increasing the threat to groundwater of COCs including metals, radionuclides, and P4. Hydraulic barriers could potentially be used to minimize the impacts to groundwater. Significant water use for equipment decontamination would require wastewater treatment, storage, and disposal. These water management issues would affect the evaluation of conventional excavation effectiveness, implementability, cost and other decisional criteria.

2.2.1.2 Hydraulic or Wet Dredging Excavation

Hydraulic excavation or wet dredging could be used, and has been used by FMC in the past on a limited basis at former ponds, provided the particle sizing is not too extreme (e.g., areas with pit-run slag could probably not be wet dredged.). The process involves mechanically mixing the phosphorus-rich soil/sludge with water at the point of excavation and transportation of the mixture through a pipeline to the treatment process. Since P4 is solid, but reactive, at ambient temperatures, it must either be chopped by a cutter head or melted using steam to allow pumping by a dredge. Solids in the mixture, typically ranging from 20% to 30%, are removed for treatment from the slurry by a complex process. The recovered water is returned to the excavation for reuse (Rhodia, 2007). Wet dredging has a benefit over conventional excavation in that P4-impacted soils are less likely to be exposed to ambient air, because the excavation working face is covered with water. Soil exposure to ambient air nevertheless can occur under this option. A further concern is P4 hydrolysis in the water, which would form PH_3 and create worker exposure risks. Controlling the risks from this potential PH3 formation could require, among other actions, construction of a temporary cover structure over the excavation site.

While performing wet dredging, large quantities of water would be added to the dry soils containing P4 so that the dredging could occur and so they could be pumped to the treatment system. Wet dredging would provide significant hydraulic head on existing contaminants, significantly increasing the threat to groundwater of the site COCs including metals, radionuclides, and P4. Hydraulic barriers could potentially be used to minimize this potential impact. In addition, the slurry would have to be dewatered prior to stabilization or solidification (S/S) treatment. The use of large quantities of water would require wastewater treatment, storage, and disposal. Sufficient cost would need to be incorporated into the capital and O&M evaluation to account for the measures necessary to address wastewater management and minimize the impacts to groundwater, even if wet dredging otherwise met the remedial action decision criteria. A further and significant concern is that any wet dredging alternative would be very likely to cause migration of COCs to groundwater.

2.2.1.3 P4-Impacted Soil Transport and Storage

Following conventional or hydraulic excavation, P4-impacted materials would need to be transported, stored, sampled, sized, and blended prior to treatment. A storage area (stockpile, storage vessels, or temporary surface impoundment) would be necessary because any ex-situ treatment process would require a continuous feed stream, and therefore feed surge capacity, to allow effective and efficient treatment. The feed material for treatment would vary greatly in P4 content depending on the area of the plant from which it came. This variability is described in Section 1.3.

Transport to a centralized, on-site treatment process would be by covered haul truck, tanker, or pipeline. Because P4-impacted materials are reactive, often acidic (due to the phosphoric acid generation), and can freeze during cold weather, the transporting vessels/pipelines would require significant maintenance efforts throughout the remediation process. The P4-impacted material would require blanketing by water, inert gas (e.g., nitrogen) or an air-tight mechanical enclosure to prevent exposure to oxygen during transport prior to treatment.

If ex-situ treatment were to be performed off-site (e.g., incineration), transport to the treatment facility would likely be by truck or rail. Again, as discussed above, the transporting vessels would require significant, ongoing monitoring for fire and corrosion. Ongoing maintenance would have to be performed because of the caustic and corrosive nature of the P4 wastes. There would be worker, public, and environmental dangers associated with off-site transport of wastes containing P4. Some major accidents have occurred during transportation of P4, notably train derailments at Brownston, Nebraska and Miamisburg, Ohio, both of which caused large fires (Wikipedia.com). These considerations indicate serious concerns regarding the effectiveness and implementability of an off-site shipment and treatment option which involved any significant amount of waste, e.g., a large number of truck loads would increase these risks. Cost considerations also would be significant. Sufficient cost would need to be incorporated into the capital and O&M estimates to account for equipment redundancy, specialized maintenance facilities capable of handling P4-contaminated equipment, and storage equipment needed to safely transport and store the P4-impacted materials.

2.2.1.4 P4-Impacted Soil Treatment Feed Sizing

As described above in Section 1.3, the soils and fill materials containing P4 vary greatly across the FMC Plant Site. While precipitator slurry and phossy solids are typically fine-grained and relatively uniform, other fill materials such as slag, coke, and ore vary considerably in particle size (1/4-inch to +6 inches). In areas where crushed slag is used as cover or fill, the crushed slag over time tends to amass and form large monolithic material blocks several feet in diameter, as was observed in RU22c in the SRI, actually preventing excavation with a standard back hoe. For any treatment process to work safely and effectively, a uniform feed particle size would be required to ensure adequate mixing, complete reaction, and transfer of heat of reaction. As such the feed would require crushing and screening prior to treatment. While such equipment can be designed to operate in a "closed" manner to prevent contact with air, experience has shown that significant equipment reliability and maintenance issues will exist. In addition to determinations regarding the other decision criteria, sufficient cost would need to be incorporated into the capital and O&M estimates to account for equipment redundancy and specialized maintenance facilities that would be capable of handling P4-contaminated soils and fill equipment.

2.2.1.5 P4-Impacted Soil Treatment Feed Sampling and Blending

As described above in Section 1.3, concentrations of P4 in the soils and fill materials vary greatly across the FMC Plant Site. Soils and fill materials containing as low as 20 ppm of P4 and as high as 50% P4 may be encountered, or potentially higher in the case of piping. Any treatment process for these materials will entail specification of an effective operating range for the concentration of P4 in the feed stream (and commensurate feed of other reactants). Thus, the P4 concentration in the feed stream would have to be sampled to determine P4 concentrations and blended with other waste streams or inert materials to provide consistent feed P4 concentrations within the specified effective operating parameters. These steps would be necessary to allow for treatment process control, especially when dealing with high P4 concentration soils (e.g, feed of higher-than-specified P4 to the reaction could result in excess temperature, pressure, fire, or release). While such blending equipment can be designed to operate in a "closed" manner to prevent contact with air, experience has shown that significant equipment reliability and maintenance issues will exist. As part of the overall evaluation of any ex-situ treatment option, there would need to a consideration and quantification of the capital and O&M costs associated with equipment redundancy, specialized maintenance facilities capable of handling P4-contaminated equipment, and a process laboratory capable of providing timely P4 analysis for process control.

2.2.2 Site Worker Health and Safety

Site worker safety is one of the most difficult elements to resolve with respect to "active" ex-situ or in-situ handling and treatment of P4-contaminated soils. Skilled site workers are essential for any successful ex-situ or in-situ treatment process, because the potential processes are complex and mostly unproven. In the context of the FMC Plant Site with unproven technologies, unique site contaminants, and handling challenges associated with widely varying P4 concentrations (even within a small area), it would be difficult to build-in the proper design and operating procedures to ensure worker safety.

P4 (solid, liquid, and vapor phases) and P4 reaction products (P_2O_5, other phosphorus oxides, phosphine, and phosphoric acid) present immediate physical hazards to site workers. These have been identified in the site-specific risk assessments performed by EPA (RI Report, 1996) and FMC (SRI Report, 2007) and by numerous medical, research, and environmental agencies including the Center for Disease Control and Prevention (CDC), the USEPA Integrated Risk Information System (IRIS), and the Cold Regions Research Engineering Laboratory (CRREL). These risks have been well documented by FMC and others that manufacture or formerly manufactured P4 in a commercial/ industrial setting, including Stauffer (Rhodia), Monsanto, and Albright and Wilson.

P4 is relatively safe when maintained under water and using well-engineered process equipment, experienced operators, and established procedures. However, when not under a blanket of water or other inert material, the P4 operations and maintenance personnel necessary for the remediation activities would potentially be exposed to widely ranging physical risks due to the nature and extent of P4 throughout the FMC Plant Site area. The largely uncontrolled conditions during excavation would expose workers to fire, dermal, and respiratory hazards. Workers in enclosures would be required to wear Level A PPE, although significantly modified (if practical) to protect them from P4 thermal exposure (e.g., most Level A protective suits do not protect against P4 burns). P4 protective suits worn at most P4 manufacturing plants were constructed with an aluminum coating, designed to be immediately shed in the event of P4 exposure. This approach would not be consistent with most PPE decontamination procedures typically applied within remediation exclusion zones or contamination reduction zones. Well-designed processes, highly-trained site workers, and a comprehensive Environmental, Health, and Safety Management System (including extensive health, safety and environmental procedures) would be critical, but might not be sufficient to ensure adequate protection of site workers. Cost considerations also would be significant, requiring quantification of the capital and O&M costs associated with providing adequate site worker protective systems if indeed such systems could be designed and reliably implemented.

2.2.3 Public Health and Safety

During operation of the FMC plant, public health and exposure often were controlled by the same measures that FMC put into place to keep plant workers safe. Typical engineering controls prevented public access to hazardous areas throughout the site (e.g., fencing). Air monitoring and scrubbers were installed to meet Clean Air Act requirements to control phosphorus-related and other air emissions from the plant site. During any remedial action that involved the handling of P4-contaminated soils, engineering controls also would be in place to protect site workers. However, unlike the controlled manufacturing process, excavation and treatment of P4 wastes could cause uncontrolled releases, especially to the air, due to the widely varying site conditions and difficulty in designing appropriate engineering controls. The risk of uncontrolled air releases would increase with the quantity of P4-soils being remediated, as well as the degree of impact, e.g., active remediation of higher concentrations of P4 in impacted materials and greater quantities of impacted materials has greater risk than active remediation of lower concentrations and smaller quantities. Some of these difficulties are discussed above and in other reports (Rhodia, 2007). Short-term public exposures to airborne contaminants including

P_2O_5, phosphine gas, and phosphoric acid also might occur, due to the many unforeseen circumstances that could arise.

2.2.4 Environmental Impacts

Environmental concerns related to the handling of P4-contaminated soils include potential impacts to air and water/groundwater. Possible worker risks from direct exposure to pure P4, phosphorus gases, and contaminated process water and risks to the public from air emissions and impacted groundwater are described above. The following discussion addresses the release mechanisms potentially triggered by active or intrusive remediation of P4-containing soils, which often also contain heavy metals and radionuclides, and the resulting potential on- and off-site impacts.

Air Impacts: Air impacts include those from dust and from phosphorus-related gases that any active treatment process would generate. During excavation, dust could be released from the excavation and sizing operations. The dust could contain P4, radionuclides, and heavy metals in varying concentrations. Although dust suppression measures would be a part of any remediation alternative, it is likely that some dust would be released during these activities.

Intrusive remediation into P4-impacted soils, including excavation, grinding, and/or sizing, would result in P4 reaction gases including P4 vapor, P_2O_5, and phosphine being released to the atmosphere. Their concentrations would depend in large part on the amount of P4 contamination, the quantity of P4-impacted soils being remediated, and the effectiveness of the engineering controls at the excavation, storage and processing areas. If these gases were to be captured and treated by a scrubber, the scrubber water would need to be treated in a waste water treatment (WWT) process. The WWT process typically would consist of neutralization (because of phosphoric acid capture by the scrubber), clarification, and sand filtration. Solids are removed by that process and consolidated by a filter press, then transported and disposed in a landfill depending on analytical testing. This material could be high in heavy metals and/or radionuclides. The water would be discharged for reuse in scrubber operations, directly discharged to the groundwater or surface water, or sent to a publicly-owned treatment works (POTW) for later discharge to surface water.

Water/Groundwater: Water would be necessary during most steps of a P4 material handling process to prevent P4 exposure to oxygen in the air and resulting combustion. Water also would be necessary for dust suppression during many of the material handling processes, such as mechanical excavation and material sizing.

During wet excavation, water would be added to allow excavation and transform the dry P4-contaminated soil from a dry solid to a slurry that could be pumped to the storage area or treatment process. During conventional excavation, water would be added to each bucket load to submerge the P4 material prior to transfer to a truck trailer. Water again would be necessary in the tank or truck trailer to prevent P4 ignition. In the sizing and storage area, water might be used in the sizing process or used to cover the P4-contaminated soil. Prior to the treatment process, water might be removed to provide the correct moisture in the feed stock. Water also would be used in the scrubbers that would be necessary to control emissions of P4-related gases

at any locations in the handling process, such as the excavation and storage areas, where such emissions would occur.

Water therefore would be added to or removed from the feed stream depending upon in the process stage. Process water might be lost to the environment during any phase of the excavation, transportation, storage, and/or treatment process. If released, process water would provide hydraulic head to mobilize P4. The hydraulic head also could mobilize heavy metals and possibly radionuclides, with the potential that they could be transported to the shallow groundwater.

Section 3.0 Elemental Phosphorus Treatment Technologies – Soils and Solids

This section presents an overview of the technologies that have been identified as candidates for treatment of elemental phosphorus-contaminated soil and solids at the FMC Plant OU. It includes a description of each technology, the process steps required to implement the technology, potential factors affecting its implementability, residual and by-products created by the treatment process, and a description of the historical use of the technology for treating P4-impacted soils. (Note that for this document, "P4-impacted soils" is intended to include all soils and/or fill materials that are contaminated with elemental phosphorus).

Commercially available (e.g., off-site incineration) technologies were identified that have been used to reduce the concentration, volume, or mobility of elemental phosphorus. In addition, technologies were identified that are not commercially available for treating P4 but may have potential applicability (e.g., ex-situ stabilization/solidification). Although containment technologies such as capping have been widely used for isolating elemental phosphorus and reducing its mobility in the environment, they are not discussed because only treatment technologies are considered in this section.

Both ex-situ and in-situ technologies may be applicable for treatment of soil and fill materials containing elemental phosphorus. Ex-situ technologies require the excavation of soil and solids followed by an above-ground treatment technology. As described in Section 2, implementing ex-situ technologies requires additional process steps such as excavation and storage that are not required for in-situ technologies. Ex-situ technologies also require that a portion of the site be used and potentially impacted to implement the technology, including possible staging areas for treatment equipment and soil stockpiles. In-situ technologies require the addition (e.g., injection) of physical, chemical, or biological agents directly to the soil without removal of the soil. In-situ technologies would need to consider the effects of the treatment on the physical and chemical characteristics of the subsurface. Some technologies, such as stabilization and solidification, have been demonstrated to be performed in-situ or ex-situ although not for P4.

The following six specific treatment technologies considered for discussion utilize physical, chemical, or thermal processes to treat elemental phosphorus:

- Solidification/Stabilization (S/S) – S/S is a commercially available chemical fixation technology commonly used to treat heavy metals and radionuclides in matrices such as soils and sludge by the addition of cementious material (e.g., Portland cement). While typically used ex-situ, S/S also may be implemented by injecting and mixing stabilizing agents into unexcavated soil or sludge. Ex- situ S/S was identified in the original EMF FS for the FMC Subarea as a technology but was only retained for further evaluation for treatment of non-P4-contaminated soils and solids. S/S was not retained for materials containing elemental phosphorus (e.g., the old phossy waste ponds) due to high short-term risks and related increased costs for mitigation of these risks. For these reasons a containment remedy was selected for P4 solids. In-situ S/S was selected for the P4-

impacted soils at the Stauffer Tarpon Springs site, but upon attempted implementation it created significant short-term hazards leading to termination of that approach. A containment remedy was ultimately selected for Tarpon Springs.

- Mechanical Aeration – A mechanical aeration system has been suggested by the USACE that could be used to increase the exposure of elemental phosphorus to oxygen and increase the rate of oxidation. Although mechanical aeration could be used either in-situ or ex-situ, studies conducted by the United States Army Corps of Engineers (USACE) only involve ex-situ aeration. Mechanical aeration was not considered during the original EMF FS.

- Caustic Hydrolysis – Caustic hydrolysis was the treatment technology selected for the Land Disposal Restriction (LDR) Treatment Plant that FMC designed and constructed, but never operated due to the plant shutdown in 2001, to treat phosphorus-containing process waste streams at its Pocatello plant. Hydrolysis was identified in the original EMF FS for the FMC Subarea as a technology but was only retained for further evaluation for treatment of non-P4-contaminated soils and solids. Hydrolysis was not retained for materials containing elemental phosphorus (e.g., the old phossy waste ponds) due to high short-term risks and related increased costs for mitigation of these risks. The EMF FS lead to selection of a containment remedy for P4 solids. This technology is only considered as an ex-situ treatment technology due to the reaction mechanisms of caustic hydrolysis.

- Chemical Oxidation – Chemical oxidation is a technology that has been implemented at the bench scale to oxidize elemental phosphorus. The Tennessee Valley Authority (TVA), the University of Alabama and the USACE have performed bench-scale and pilot scale studies on various types of oxidants for treating elemental phosphorus. Chemical oxidation was identified in the original EMF FS for the FMC Subarea as a technology, but was only retained for further evaluation for treatment of non-P4-contaminated soils and solids. Chemical oxidation was not retained for materials containing elemental phosphorus (e.g., the old phossy waste ponds) due to high short-term risks and related increased costs for mitigation of these. This was another factor supporting selection of a containment remedy for P4 solids.

- Incineration - Incineration has been identified by the United Nations as a viable method for treating elemental phosphorus-containing waste (ARSDR, 1997). Incineration is a commercially-available thermal treatment technology that could be used to oxidize P4 and reduce the volume of material requiring further treatment or disposal. Incineration was identified in the original EMF FS for the FMC Subarea as a technology, but was not retained for further evaluation due to high-short term risks and related increased costs for mitigation of these risks, findings that contributed to the selection of a containment remedy for P4 solids. Off-site incineration was used to dispose of containerized P4-containing materials generated while cleaning process equipment during FMC plant decommissioning.

- Thermal Desorption – Thermal desorption is a commercially available technology that involves heating soil to cause contaminants to volatilize and separate from the solid matrixes without combustion. Thermal Desorption was identified in the original EMF FS for the FMC Subarea as a technology but was not retained for further evaluation due to high-short term risks and related increased costs for mitigation of these risks, again supporting selection of a containment remedy for P4 solids. Thermal desorption has been used on a small volume basis for P4 associated with munitions at the Defense Depot Ogden, Utah (DDOU) site.

In this section, a screening-level evaluation of P4 treatment technologies is presented. For each technology identified, information is provided (to the extent known based upon literature research and FMC experience) on the following topics:

- Description of the treatment process as utilized in ex-situ and/or in-situ applications, as applicable.

- Description of the complete treatment process sequence. This is intended to provide information on the complete process train necessary to implement the technology. This can include steps such as excavation, storage, transportation, waste management, and use of specialized equipment. In some cases, the ancillary processes may present the biggest engineering challenges.

- Description of the engineering challenges and issues for application of the treatment technology to P4-impacted soils and fill materials.

- Description of the treatment technology performance and limitations. This is intended to provide guidance on where the treatment technology may be applicable and which site conditions would limit its potential use.

- A description of whether and how the technology has been put to actual use, including the state of its development and any actual cases where the technology has been applied to P4-impacted soils and/or fill materials. Note that no testing of technologies was performed as part of this screening evaluation.

3.1 STABILIZATION AND SOLIDIFICATION

Stabilization and solidification (S/S) is an established technology for treatment of organics, heavy metals and radionuclides (for example, see the Solidification/ Stabilization Resources Guide; EPA, 1999 and Solidification/ Stabilization Use at Superfund Sites; EPA 2000). It has been identified as a possible technology for treating P4 both in-situ and ex-situ.

3.1.1 S/S Treatment Process

S/S involves mixing a waste with binding agents (i.e., pozzolanic materials), such as Portland Cement or fly ash, to create a slurry, paste, or semi-liquid and then providing curing time and

conditions for the mixture to set into a solid form. Although generally performed ex-situ in a pug mill, S/S can be performed in-situ using augers or backhoes to inject and mix the stabilizing agent in place.

S/S reduces the mobility of contaminants in a matrix through chemical or physical processes. The S/S process physically binds or encapsulates contaminants using a pozzolanic material within a stabilized mass to prevent further migration. It also chemically converts the contaminants into less soluble, mobile, or toxic forms.

3.1.2 Complete S/S Process Treatment Sequence

The complete ex-situ S/S treatment sequence as applied at the FMC Plant Site would be a complex process operation involving: 1) the excavation (or wet dredging) of the P4-impacted material, 2) transport of the material to the treatment location, 3) storage of the excavated material to provide feed surge to the treatment process, 4) sizing (e.g., crushing and screening) of the material to provide a consistent feed particle size to the treatment process, 5) sampling and blending with other extracted streams or inert materials of the feed to provide consistent P4 content, 6) S/S treatment, 7) curing to allow time for solidification, 8) transportation to the final disposal site, and 9) landfill disposal.

The complete in-situ S/S treatment sequence would involve injecting the cementious material and water into the contaminated soil while providing mechanical mixing in place.

In the case of applying S/S treatment technology to P4-impacted materials, the mobility of P4 would be reduced in some part due to the hydrolysis reaction of P4 with the alkali admix and in some part due to encapsulation of P4 within the hardened concrete. Off-gassing of PH_3 will result from that portion of the P4 which undergoes caustic hydrolysis. For both in-situ and ex-situ S/S, phosphorus off-gas capture, scrubbing, and wastewater treatment systems would likely be necessary at the point of treatment and likely at the point of excavation and temporary storage for ex-situ treatment, dependent on the quantity of waste being managed as well as the P4 concentration in the waste.

3.1.3 Engineering Challenges/Issues for S/S

The following discussions provide preliminary analysis of the engineering challenges and issues if S/S were applied to P4-impacted soils at the FMC Plant Site.

3.1.3.1 Ex-Situ S/S Treatment As Applied to P4-Impacted Soils

<u>Ancillary process options associated with S/S ex-situ treatment:</u> If ex-situ S/S treatment were performed, the engineering considerations with respect to S/S applied to P4-contaminated soil would include one or more of the following ancillary process options (and associated engineering challenges/issues):

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2);
- Excavated soil transport and storage (see Section 2.2.1.3);
- Treatment feed sizing (see Section 2.2.1.4); and
- Treatment feed sampling and blending (see Section 2.2.1.5).

Ex-situ S/S treatment: The ex-situ treatment process would also present some significant engineering challenges, even with a consistent feed particle size and P4 concentration. The reaction of P4 with alkaline cementious materials will result in significant releases of reaction products (i.e., P4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4). These reactions would have to be carefully controlled in the process and the resulting emissions would have to be captured using the appropriate air pollution control and ancillary equipment. The remedial alternative evaluation would need to include consideration of the capital and O&M costs for equipment redundancy, specialized maintenance facilities capable of handling P4-contaminated equipment, and air pollution control equipment and operation.

3.1.3.2 In-Situ S/S Treatment As Applied to P4-Impacted Soils

If in-situ S/S treatment were performed, the engineering issues with respect to S/S applied to P4-contaminated soil would include the following:

Control of P4 reactions during injection or mixing: One of the critical process controls necessary for S/S treatment of P4 is the control of the P4 reaction, both in terms of an overly rapid reaction that results in a P4 fire, or having insufficient mixing that results in un-reacted P4. This type of process control during in-situ treatment is likely to be impossible due to a range of factors such as the variability of the P4 concentrations, the soil or fill matrix in which the P4 is located, and the difficulty of controlling in-situ reactions. In-situ S/S at the FMC Plant Site could result in one or more of the following scenarios:

- Uncontrolled excessive reaction of P4 with alkaline cementious material, resulting in a fire and threat of release of reaction products (i.e., P4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4) and/or thermal burns to remediation workers and equipment; and/or

- Incomplete mixing of cementious material with contaminated soils such that P4 is not completely reacted (i.e., it remains as P4) in the resulting solidified mass.

- Loss of free liquids that could transport other site COCs, including metals and radionuclides, to shallow groundwater.

Without extreme measures such as covering the in-situ treatment area with an impermeable structure, receptors downwind of the in-situ treatment could potentially be exposed to aerosols associated with P_4 combustion.

The most immediate threat for in-situ S/S treatment would be the thermal burning of P4 in the event of uncontrolled P4 reactions, which would pose a threat to remedial workers and

equipment. Extreme caution, including extraordinary procedures and PPE, would be required to prevent severe injury to remediation workers and damage to equipment. Evaluation of this technology as a remedial option would have to take into account the cost and other factors associated with taking the measures necessary to prevent direct exposure of remediation workers and equipment to burning P4.

Increased hydraulic head in contaminated soils: During the initial solidification process, free water is typically generated in the treated mass. This free water would likely provide a temporary hydraulic head that could carry COCs, including metals and radionuclides to groundwater. A hydraulic barrier could potentially be used to partially mitigate this impact.

3.1.4 S/S Treatment Performance and Limitations

Given the engineering challenges and issues associated with ex-situ and/or in-situ S/S treatment, the following are the limitations, advantages, and potential applications of this technology for treating P_4 contaminated soils at the FMC Plant Site:

Limitations:

- Generally not applicable for soil depth over 15 feet for ex-situ application and 20 feet for in-situ application due to limitations of construction excavation equipment and mixing auger limitations;
- Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b (both ex-situ and in-situ) due to the significant volume increase (as much as 30 %) in total waste to be managed after S/S;
- Difficult to control P4 reactions (in-situ and ex-situ) because of widely varying P4 concentrations;
- Very complex complete treatment sequence (ex-situ) due to feed material sizing, blending and off-gas management;
- P_4 associated with UG Piping could not easily be processed, as metal piping would not allow for in-situ treatment and would make wet-dredging, pumping, sizing, blending and treatment impossible. Special handling of piping containing P4 would be required; and
- Significant variation in soil particle size and P4 concentration as found in most RUs containing P4 would make the ex-situ handling process extremely complex and difficult to operate and maintain. For in-situ treatment, the particle size variation would very likely result in inadequate/incomplete mixing.

Advantages:

- Also stabilizes metals and radionuclides present in the soil/fill matrix (both in-situ and ex-situ) although would not likely be effective at addressing gamma.
- Ex-situ process would recover free water during processing, and thus would not present the risk associated with in-situ S/S treatment of creating a hydraulic head and adding contamination to underlying soils and groundwater, assuming risks associated of using water during excavation were otherwise addressed

Potential applicability:

- Shallow soils with low concentration P_4 (< 10,000 ppm);
- Shallow soils with consistent material sizing and concentration of P4; and
- Relatively low volumes of wastes.

3.1.5 By-Products and Residuals

In any treatment process, the by-products and residuals must be addressed in the feasibility evaluation and cost. The following by-products and residuals would be expected from the S/S treatment process:

Ex-situ:

- Solidified mass consisting of other fill materials (containing bound metals, radionuclides, and inert materials), unreacted cementious material, and insoluble calcium phosphate;
- P4 reaction air emissions including PH_3, P_20_5, H_3PO_4, and H_2;
- Contaminated water used for storing and transporting recovered soils, dewatering, and air pollution control that would require treatment; and
- Air pollution control system sludges.

In-situ:

- Solidified mass consisting of other fill materials (containing bound metals, radionuclides, and inert materials), unreacted cementious material, and insoluble calcium phosphate;
- P4 reaction air emissions including PH_3, P_20_5, H_3PO_4, and H_2;
- Free liquids potentially containing metals, radionuclides and dissolved/particulate P4.
- Air pollution system control wastewaters and sludges.

3.1.6 History of Use

S/S is a widely used treatment for the management/disposal of a broad range of contaminated media and wastes including metals and radionuclides (Wilk, 2004). However, there has only been one documented case of using S/S on soils contaminated with elemental phosphorus. S/S was selected along with excavation and consolidation as the recommended remedial alternative for the Stauffer Management Company (SMC) Superfund site. The SMC superfund site was the former location of a WP manufacturing site in Tarpon Springs, Florida.

At the Tarpon Springs site, a two-stage process was performed involving the identification of a S/S mix design and implementation of an in-situ S/S. In February 2006, SMC conducted a full-scale field study for in-situ solidification and stabilization within a former pond containing sludge and soil containing elemental phosphorus. An 8.5 foot auger was used to inject and mix a cement slurry into contaminated soil and materials to a depth of 20 feet. As a result of the cement curing, the elemental phosphorus ignited and created a persistent fire that was eventually

extinguished. The fire caused the generation of PH_3 gas, though the levels were not high enough to warrant evacuation of nearby residents. Because of the violent and poorly controllable chemical reactions the field-scale study was discontinued. EPA issued an Explanation of Significant Differences (ESD) documenting its decision to abandon in-situ S/S at that site and replace it with capping and a hydraulic barrier. The ESD approved the construction of a cut-off wall and cap as replacement for the in-situ S/S remedy (FDEP, 2006).

3.2 MECHANICAL AERATION

Mechanical Aeration has been identified as a possible technology for treatment of P4 in soil. The process could potentially be performed both in-situ and ex-situ.

3.2.1 Mechanical Aeration Treatment Process

Mechanical aeration involves the use of physical equipment, such as a mixer, to agitate a solid or slurry material and expose the material to the atmosphere, causing ambient oxygen to react with the P_4 contained in the solid matrix and oxidize the P_4. Mechanical aeration would convert P_4 to various phosphate compounds. Aeration also would convert P_4 to phosphine and P_2O_5 (EPA, 2003). Mechanical aeration would involve exposing P_4 particles in the soil to oxygen.

The USACE indicated that a mechanical aeration system could be used ex-situ or in-situ to expose elemental phosphorus to oxygen (Rivera, 1996). However, further studies would be required to determine how the degradation of elemental phosphorus is affected by concentrations of dissolved oxygen, mixing rate, matrix characteristics, depth of material, temperature, and pH. An in-situ mechanical aeration system could be used to increase the dissolved oxygen (DO) in the soil. This would result in increasing the oxygen availability to the P_4 in the soil, accelerating the degradation rate of P_4. Mechanical aeration would not be effective at treating radionuclides and heavy metals.

3.2.2 Complete Mechanical Aeration Process Treatment Sequence

The complete ex-situ mechanical aeration sequence would be a complex process operation that would involve: 1) the excavation (or wet dredging) of the P4-impacted material, 2) transport of the material to the treatment location, 3) storage of the excavated material to provide feed surge to the treatment process, 4) sizing (e.g., crushing and screening) of the material to provide a consistent feed particle size to the treatment process, 5) sampling and blending with other extracted streams or inert materials of the feed to provide consistent P4 content (i.e., percentage of P4), 6) mechanical aeration treatment, 7) transportation to the final disposal site, and 8) landfill disposal. In addition, soils treated with mechanical aeration likely would require further treatment for radionuclides and metals prior to disposal.

The complete in-situ mechanical aeration treatment sequence would involve injecting air into the contaminated soil while providing mechanical mixing in place.

For both in-situ and ex-situ mechanical aeration, phosphorus off-gas capture, scrubbing, and wastewater treatment systems would be necessary at the point of treatment and likely at the point of excavation and temporary storage for ex-situ treatment.

3.2.3 Engineering Challenges/Issues for Mechanical Aeration

The following discussions provide a preliminary analysis of the engineering challenges and issues if mechanical aeration were applied to P4-impacted soils.

3.2.3.1 Ex-Situ Mechanical Aeration Treatment As Applied to P4-Impacted Soils

Ancillary process options associated with mechanical aeration ex-situ treatment: If ex-situ mechanical aeration treatment were performed on P4-impacted materials, the ancillary process options (and associated engineering challenges/issues) would include the following:

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2);
- Excavated soil transport and storage (see Section 2.2.1.3);
- Treatment feed sizing (see Section 2.2.1.4); and
- Treatment feed sampling and blending (see Section 2.2.1.5).

Ex-situ mechanical aeration treatment: The ex-situ treatment process would also present some significant engineering challenges, even with a consistent feed particle size and P4 concentration. The reaction of P4 with air will result in significant releases of reaction products (i.e., P_4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4) and possibly result in combustion of P_4. These reactions would have to be carefully controlled in the process and the resulting emissions would have to be captured and controlled using the appropriate air pollution control and ancillary equipment. The remedial alternative evaluation would have to account for needed equipment redundancy, specialized maintenance facilities capable of handling P4-contaminated equipment, and air pollution control equipment.

3.2.3.2 In-Situ Mechanical Aeration Treatment As Applied to P4-Impacted Soils

If in-situ mechanical aeration treatment were applied to P4-contaminated soil, the engineering issues would include the following:

Control of P_4 reactions during injection or mixing: One of the critical process controls necessary for mechanical aeration treatment of P_4 is the control of the P4 reaction, both in terms of an overly rapid reaction that results in a P4 fire or having insufficient injection and mixing of air that results in un-reacted P_4. This type of process control during in-situ treatment is likely to be impossible, resulting in one or both of the following scenarios:

- Uncontrolled excessive reaction of P_4 with air, resulting in a fire and the threat of release of reaction products (i.e., P_4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4) and/or thermal burns to remediation workers and equipment; and/or

- Incomplete mixing of air with contaminated soils such that P_4 is not completely reacted (i.e., it remains as P_4) in the soil.

Without extreme measures such as covering the in-situ treatment area with an impermeable structure, receptors downwind of the in-situ treatment could be exposed to aerosols associated with P_4 combustion. The remedial alternative evaluation would need to consider the measures necessary to prevent exposure of P_4 reaction products to remediation workers and the public.

The most immediate threat for in-situ mechanical aeration treatment would be the thermal burning of P_4 in the event of uncontrolled P_4 reactions, which would pose a threat to remedial workers and equipment. Extreme caution, including extraordinary procedures and PPE, would be required to prevent severe injury to remediation workers and damage to equipment. Evaluation of this remedial option would need to address the measures necessary to prevent direct exposure of burning P_4 to remediation workers and equipment.

3.2.4 Mechanical Aeration Treatment Performance and Limitations

Given the engineering challenges and issues associated with ex-situ and/or in-situ mechanical aeration treatment, the following limitations, advantages, and potential applications are identified for P4-contaminated soils at the FMC Plant Site:

Limitations:

- Generally not applicable for soil depth over 15 feet for ex-situ application and 20 feet for in-situ application due to limitations of construction excavation equipment and mixing auger limitations.

- Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b (both ex-situ and in-situ) due to the material handling challenges on that scale.

- Difficult to control the P4 reactions (in-situ and ex-situ) because of widely varying P4 concentrations.

- Significant variation in soil particle size and P4 concentration as found in most RUs containing P4 would make the ex-situ handling process extremely complex and difficult to operate and maintain. For in-situ treatment, the particle size variation would result in inadequate/incomplete mixing.

- Would not treat metals and radionuclides that are present in the P_4-contaminated soils.

Advantages:

- Does not require the injection of costly additives, potentially making it easier to implement in low porosity material.

Potential applicability:

- Shallow soils with low (< 10,000 ppm) and generally uniform levels of P4.
- Shallow soils with consistent material sizing.

3.2.5 By-Products and Residuals

In any treatment process, the by-products and residuals must be addressed in the feasibility evaluation including cost analysis. The following by-products and residuals would be expected from the mechanical aeration treatment process:

Ex-situ:

- Soil potentially requiring additional treatment for metals and radionuclides prior to disposal;

- P4 reaction emissions including PH_3, P_20_5, H_3PO_4, and H_2;

- Contaminated water used for storing and transporting recovered soils, dewatering, and air pollution control; and

- Air pollution control system sludges.

In-situ:

- P4 reaction air emissions including PH_3, P_20_5, H_3PO_4, and H_2;

- Air pollution system control wastewaters and sludges.

3.2.6 History of Use

The USACE has stated that mechanical aeration has not been field tested, and that the feasibility of applying this to WP-contaminated sediments would need additional research and experimental work. It has not suggested a design for in-situ mechanical aeration treatment (Rivera, 1996). However, several bench scale studies have been conducted to relate the amount of dissolved oxygen (DO) to the degradation of WP. Lai (1979b) conducted a study to evaluate the degradation rate of WP in solutions by manipulating the amount of DO in the samples. The study indicated that mechanical aeration would reduce the concentration of WP in aqueous solution from near 1,000 μg/L to less than 10 μg/L in 60 days. However, these studies were performed on aqueous solutions containing a generally low and homogenous concentration of WP. Attempting to treat P4-contaminated soil with mechanical aeration may produce different results.

3.3 CAUSTIC HYDROLYSIS

Caustic Hydrolysis is a chemical process in which elemental phosphorus is dissociated and reacts with hydrogen and/or hydroxyl ions in solution. Hydrolysis reactions are typically catalyzed with acids or bases. In addition, increased temperature and pressure typically increase the rate of reaction. FMC previously identified and used caustic hydrolysis (using slaked lime) to treat P4-containing production waste streams (specifically precipitator slurry). Hydrolysis of P4 produces various forms of phosphorus compounds (i.e., phosphites and phosphates), as well as phosphine gas. Because the P4 hydrolysis reaction rate is significantly higher at elevated temperatures, caustic hydrolysis is only considered as an ex-situ treatment technology.

3.3.1 Caustic Hydrolysis Treatment Process

Contaminated P4 soils would be transferred to a stirred batch reactor and heated to a temperature greater than 140°F. A source of hydroxide ion (typically lime) and water then are added, while continuing to stir the reactor contents. A pH of approximately 11 is maintained. Caustic hydrolysis would convert P_4 in soil to various phosphite and phosphate compounds, and heavy metals to metal oxides and hydroxides. The phosphine and hydrogen gas produced by this process are typically combusted in a thermal oxidizer, forming water vapor and P_2O_5. The P_2O_5 is then scrubbed with water, producing a phosphoric acid stream which can be neutralized or potentially sold as product.

3.3.2 Complete Caustic Hydrolysis Process Treatment Sequence

The complete ex-situ caustic hydrolysis sequence would be a complex process operation involving: 1) the excavation (or wet dredging) of the P4-impacted material, 2) transport of the material to the treatment location, 3) storage of the excavated material to provide feed surge to the treatment process, 4) sizing (e.g., crushing and screening) of the material to provide a consistent feed particle size to the treatment process, 5) sampling and blending with other extracted streams or inert materials of the feed to provide consistent P4 content, 6) caustic hydrolysis treatment, 7) transportation to the final disposal site, and 8) landfill disposal. In addition, soils treated with caustic hydrolysis may require further treatment for radionuclides prior to disposal.

For caustic hydrolysis treatment, phosphorus off-gas capture, scrubbing, and wastewater treatment systems would be necessary at the batch reactor and likely at the point of excavation and temporary storage.

3.3.3 Engineering Challenges/Issues for Caustic Hydrolysis

The following discussions provide a preliminary analysis of the engineering challenges and issues if mechanical aeration were applied to P4-impacted soils.

3.3.3.1 Caustic Hydrolysis Treatment As Applied to P4-Impacted Soils

Ancillary process options associated with caustic hydrolysis ex-situ treatment: If ex-situ caustic hydrolysis treatment were performed on P4-impacted materials, the ancillary process options (and associated engineering challenges/issues) would include the following:

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2);
- Excavated soil transport and storage (see Section 2.2.1.3);
- Treatment feed sizing (see Section 2.2.1.4); and
- Treatment feed sampling and blending (see Section 2.2.1.5).

Caustic hydrolysis treatment: The treatment process would also present some significant engineering challenges, even with a consistent feed particle size and P4 concentration. The reaction of P4 with a caustic solution will result in significant releases of reaction products (i.e., P4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4). The resulting emissions would have to be captured and controlled using the appropriate air pollution control and ancillary equipment, including a thermal oxidizer for phosphine and hydrogen conversion and a scrubber for capturing the resulting P_2O_5 and producing phosphoric acid. Evaluation of this technology as a remedial option would have to take into account cost and other factors associated with the needed equipment redundancy, specialized maintenance facilities capable of handling P_4-contaminated equipment, and air pollution control equipment.

3.3.4 Caustic Hydrolysis Treatment Performance and Limitations

Given the engineering challenges and issues associated with ex-situ caustic hydrolysis, the following limitations, advantages, and potential applications are identified for P4- contaminated soils at the FMC Plant Site:

Limitations:

- Generally not applicable for soil depth over 15 feet for ex-situ application due to limitations of construction excavation equipment.

- Extremely complex complete treatment sequence including all the ancillary treatment processes (feed preparation, reactant preparation, waste slurry management, air emissions management).

- Difficult to supply consistent (size and concentration) P4 feed stream and therefore control P4 reactions.

- Significant variation in soil particle size and P4 concentration, as found in most P4-containing RUs, would make the handling process extremely complex and difficult to operate and maintain.

- Requires additional treatment for radionuclides at a minimum, but possibly the metal oxides and hydroxides as well.

Advantages:

- Converts heavy metals in process feed material to metal oxides and hydroxides that may not require additional treatment. Bench scale testing of treatment sludges would be necessary to evaluate if additional treatment is necessary for metal and radionuclides present in process sludges.

Potential Applicability:

- Shallow soils with low concentration P4 (< 10,000 ppm).

- Shallow soils with consistent material sizing and concentration of P4.

3.3.5 By-Products and Residuals

In any treatment process, the by-products and residuals must be addressed in the feasibility evaluation including the cost analysis. The following by-products and residuals would be expected from the caustic hydrolysis treatment process:

- Slurry/solid residue in the hydrolysis reactor bottoms stream, consisting primarily of inert dirt, un-reacted lime, and insoluble calcium phosphite ($CaHPO_3$) would require further stabilization;

- The wastewater generated from the caustic hydrolysis treatments would contain suspended solids and soluble calcium hypophosphite that would require treatment and disposal;

- Gases produced during hydrolysis include phosphine (PH_3), hydrogen (H_2), and water; and

- Air pollution control system sludges.

3.3.6 History of Use

A full-scale caustic hydrolysis system has been in operation since 2000 at the GSHI facility in Columbia, Tennessee to treat a low concentration P4 furnace production process waste stream (Rhodia, 2007).

Beginning in the mid-1990s, FMC began using lime treatment of precipitator slurry in the furnace precipitator dust "slurry pots" principally to increase the pH of the precipitator slurry and decease the solubility of metals within the precipitator solids. The lime treatment was termed Non-hazardous Slurry Assurance Project or "NOSAP." The lime addition also catalyzed

hydrolysis of P4 within the precipitator solids causing generation of PH3 from the lime-treated precipitator slurry. Under the RCRA Consent Decree, certain operating criteria, including volume of lime addition, temperature, final pH and retention time, were established that constituted "on-specification" NOSAP precipitator slurry. However, the RCRA Consent Decree required the development and implementation of a more rigorous treatment process for the precipitator slurry and phossy water/solids from the plant due, in part, to EPA's position that the NOSAP process did not meet EPA's treatment objectives. EPA's conclusion that additional treatment was required led to the RCRA Consent Decree requirement that FMC design, construct and operate what was referred to as the LDR Treatment Plant to more thoroughly treat the plant process wastes. Although the LDR Treatment System was not completed or ever operated, the LDR system was intended to replace and improve upon the NOSAP process for the treatment of precipitator slurry from ongoing P4 production.

The main objective of the LDR treatment system was to treat the waste stream slurries from the furnace production process containing low levels of elemental phosphorus (less than 2% P4 and particle size less than U.S. Standard Sieve Mesh # 60) to reduce the P4 concentration. The treated, filtered and dewatered waste solids then would have undergone cement stabilization to stabilize metals and meet RCRA LDR requirements prior to disposal in an on-site landfill. As stated in Section 4.2, the LDR treatment system would have had narrow operational parameters (e.g., injection rates, particle size cutoffs, and P4 feed concentrations). It also would have involved numerous operational steps. These would have included the following: slurry feed processing in a ball mill to achieve less than 60 mesh particle size; collection and piping of the considerable amount of off-gas the caustic hydrolysis process would have generated; lime reactant preparation; chemical hydrolysis in reactor columns; reacted solids dewatering and stabilization; treatment of the off-gas management in a thermal oxidizer unit; oxidizer emissions scrubbing; and scrubber water treatment. The process was developed based on bench and pilot testing. It was never operated or demonstrated to be successful at full-scale even on the specific type of waste for which it was designed. A major process engineering review and design effort would be required in any to attempt to modify and expand that process to treat varying soil matrices that contain varying levels of P4.

3.4 CHEMICAL OXIDATION

Chemical oxidation involves the addition of chemical agents to react with COCs in the soil to form oxidized by-products. Chemical oxidation could potentially be used to treat P4 as an in-situ application or an ex-situ application.

3.4.1 Chemical Oxidation Treatment Process

Chemical oxidation involves adding uniformly sized feed material to a batch reactor where air, oxygen or acid (often nitric or sulfuric) is added, depending on the process, to react with and oxidize the P4 in the soils. In all but the High Speed Air Dispersion (HSAD) chemical oxidation process, the reaction vessel is heated to between 100 and 400°F during the batch treatment. A variety of waste streams are created depending on the type of oxidants used for the reaction. A scrubber would be needed to treat phosphorus gas emissions, and liquid wastes (scrubber water/wastewater) would need treatment or processing prior to on/off-site disposal or sale. In

general, chemical oxidation would convert P4 to various phosphate compounds. However, it would not be effective at treating metals and radionuclides.

Chemical oxidation could be performed ex-situ in a reactor vessel. Several ex-situ oxidation processes have been identified for possibly oxidizing P4, including High-Speed Air Dispersion (HSAD) for Wet Oxidation, the Praxair Oxidation Process, the Zimpro/Wet Air Oxidation Hybrid process, and nitric/sulfuric acid oxidation. The possibility has been suggested of performing chemical oxidation in-situ using a flushing process (Rhodia, 2007). Chemical oxidants would be added to the P4-contaminated soils either through injection or another method for distributing the oxidants through the contaminated medium. Although this has been used for a variety of chemicals, no information is available regarding in-situ chemical oxidation of P4-contaminated soils, and EPA did not discuss it further in the report prepared for the FMC historic ponds containing P4 in pond sediments (EPA, 2003). As with any in-situ injection technology, the effectiveness is largely dependent on the soil matrix constraints affecting the treatment criteria for physical contact and residence time between the oxidizing liquor and the targeted reactant. Given the mixed particle size in the fill materials, two issues arise. First, injection would likely take preferential pathways and not adequately contact the P4. Second, recovery of any reacted liquor likely would not be sufficient to prevent migration to groundwater.

3.4.2 Complete Chemical Oxidation Process Treatment Sequence

The complete ex-situ chemical oxidation treatment sequence would be a complex process involving: 1) the excavation (or wet dredging) of the P4-impacted material, 2) transport of the material to the treatment location, 3) storage of the excavated material to provide feed surge to the treatment process, 4) sizing (e.g., crushing and screening) of the material to provide a consistent feed particle size to the treatment process, 5) sampling and blending with other extracted streams or inert materials of the feed to provide consistent P4 content (i.e., percentage of P4), 6) chemical oxidation treatment, 7) additional treatment of solids for metals and radionuclides, 8) transportation to the final disposal site, and 9) landfill disposal. Both the wastewaters and gases from the process would need additional treatment processes before being disposed of, sold or otherwise released.

The complete in-situ chemical oxidation treatment sequence would involve injecting chemical oxidants into the contaminated soil and extraction of reacted liquor

For both in-situ and ex-situ chemical oxidation, phosphorus off-gas capture, scrubbing, and wastewater treatment systems would be necessary at the point of treatment and likely also at the point of excavation and temporary storage for ex-situ treatment.

3.4.3 Engineering Challenges/Issues for Chemical Oxidation

The following discussions provide a preliminary analysis of the engineering challenges and issues if chemical oxidation were applied to P4-impacted soils.

3.4.3.1 Ex-Situ Chemical Oxidation Treatment As Applied to P4-Impacted Soils

Ancillary process options associated with chemical oxidation ex-situ treatment: If ex-situ chemical oxidation treatment were performed on P4-impacted materials, the engineering considerations would include one or more of the following ancillary process options (and associated engineering challenges/issues):

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2);
- Excavated soil transport and storage (see Section 2.2.1.3);
- Treatment feed sizing (see Section 2.2.1.4); and
- Treatment feed sampling and blending (see Section 2.2.1.5).

Ex-situ chemical oxidation treatment: Ex-situ chemical oxidation might be implemented by construction of a chemical reactor and ancillary treatment units using one of the processes mentioned above. Extensive development testing in a bench- or pilot- scale facility would be needed prior to construction of a full-scale treatment facility.

The ex-situ treatment process would present some significant engineering challenges, even with a consistent feed particle size and P4 concentration. The reaction of P4 with oxidizing agents can, depending on the chemical oxidation process and oxidant used, result in significant releases of various reaction products including H_2, P_4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4. These reactions would have to be carefully controlled in the process and the resulting emissions would have to be captured and controlled using the appropriate air pollution control and ancillary equipment (see Section 2.x above). The remedial option evaluation would have to take into account the cost and other factors associated with the needed equipment redundancy, specialized maintenance facilities capable of handling P4-contaminated equipment, and air pollution control equipment.

3.4.3.2 In-Situ Chemical Oxidation Treatment As Applied to P4-Impacted Soils

If in-situ chemical oxidation treatment were performed on P4-contaminated soil, the engineering issues would include the following:

Control of P4 reactions during injection: One of the critical process controls necessary for chemical oxidation treatment of P4 is the control of the P_4 reaction. Insufficient mixing results in un-reacted P4. This type of process control during in-situ treatment is likely to be impossible, resulting in one or all of the following scenarios:

- Incomplete mixing of chemical oxidant with contaminated soils, such that P4 is not completely reacted (i.e., it remains as P4) in the soil;

- Uncontrolled excessive reaction of P4 with air, resulting in a fire and threat of release of reaction products (i.e., P4 vapor, P_2O_5, PH_3, phosphorus oxides, and H_3PO_4) and/or thermal burns to remediation workers and equipment; and/or

- Release of free liquids during the injection process (depending on the oxidant) that could transport other site COCs including metals and radionuclides to shallow groundwater.

Without extreme measures such as covering the in-situ treatment area with an impermeable structure, receptors downwind of the in-situ treatment could be exposed to aerosols associated with P4 combustion.

The most immediate threat for in-situ chemical oxidation treatment would be the thermal burning of P4 in the event of uncontrolled P4 reactions, which would pose a threat to remedial workers and equipment. Extreme caution, including extraordinary procedures and PPE, would be required to prevent severe injury or death to remediation workers and damage to equipment. Evaluation of this technology as a remedial option would have to consider cost and other factors associated with the measures necessary to prevent direct exposure of remediation workers and equipment to burning P4.

3.4.4 Chemical Oxidation Treatment Performance and Limitations

Given the engineering challenges and issues associated with ex-situ or in-situ chemical oxidation treatment, the following limitations, advantages, and potential applications are identified for P_4 -contaminated soils at the FMC Plant Site:

Limitations:

- Very complex complete treatment sequence.
- Generally not applicable for soil depth over 15 feet for ex-situ and 20 feet for in-situ.
- Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b (both ex-situ and in-situ).
- Difficult to control P4 reactions (in-situ and ex-situ) because of widely varying P4 concentrations.
- In-situ process would involve free liquids within the soil/fill material matrix thus creating a hydraulic head resulting in potential contamination of underlying groundwater.
- Significant variation in soil particle size and P4 concentration as found in most RUs would make the process extremely complex and difficult to operate and maintain.
- Does not treat metals and radionuclides associated with P4-contaminated soils and some processes even concentrate metals in the reactor sludges.

- Generation of phosphorus related gases that need to be treated and sludges disposed.

- Liquid and solid process streams would need secondary treatment prior to disposal.

Advantages:

- None.

Potential applicability:

- Soils with low concentration P^4 (< 10,000 ppm). HSAD bench scale testing were conducted using 180 gram samples of "filtered sludge" at 3.75, 7.5, and 15 percent solids, oxygen concentrations of 20, 50, and 80 percent, and agitation intensities between 4,000 and 8,000 rpm. The sludge contained P4 at 4.4% ppm (EPA,2003).

- Soils with consistent material sizing.

3.4.5 By-Products and Residuals

In any treatment process, the by-products and residuals must be addressed in the feasibility evaluation and cost. The following by-products and residuals would be expected from a chemical oxidation treatment process:

Ex-situ:

- Sludge residues, which would require dewatering and treatment for metals and radionuclides; and

- Contaminated water generated from storing and transporting recovered soils, dewatering, and controlling air pollution during several steps in the process.

In-situ:

- Soil mass with radionuclides and elevated metals;

- P4 reaction air emissions including PH_3, P_20_5, H_3PO_4, and H_2;

- Air pollution control system wastewaters and sludges; and

- In-situ process would involve free liquids within the soil/fill material matrix that would have to be managed.

3.4.6 History of Use

Chemical oxidation of soils and solids containing P4 has only been conducted at bench and pilot scale. Two types of ex-situ oxidation technologies have been identified as potential candidates to treat elemental phosphorus; nitric/sulfuric acid oxidation and the HSAD process. The acid oxidation technology was developed and tested (pilot-scale) by the Tennessee Valley Authority (TVA) on sludge containing elemental phosphorus. The effluent from this process was then reacted with ammonia to produce a nitrogen and phosphate containing plant nutrient. The HSAD technology was developed and tested by researchers at the University of Alabama on sludge from Astaris (previously FMC), TVA, and Occidental Chemical. These processes are based on chemical transformation by oxidation.

Although the acid oxidation pilot scale study conducted by the TVA was capable of reducing the concentrations of P4, operational concerns included sludge granulation and the generation of relatively large amounts of fertilizer and nitrogen oxide gases that would require further management or disposal. In addition, the pilot plant was only capable of processing the 30,000 lbs of P4 sludge at 380 liters per batch. Tests using the HSAD chemical oxidation process were conducted using 180 gram samples of filtered sludge (4.4 % P4), oxygen (at 20, 50 and 80 percent), and agitation intensities of 4K, 6K, and 8K revolutions per minute (rpm). The results show marked decrease in P4 concentrations, but also increases in heavy metals (Jefcoat et. al., 1995). Therefore, additional treatment for metals would likely be required prior to disposing of the waste.

Any ex-situ chemical oxidation would require the excavation and preprocessing for granulation of P4. This would result in significant short-term health and safety risks.

3.5 INCINERATION

Incineration is a proven technology that is commercially available to treat hazardous wastes. Mobile incinerators also are available for use at treatment sites. Typically, the technology is used for the destruction of organic compounds such as hydrocarbons and to reduce waste volume (Cost and Performance Remediation Case Studies [FRTR, 2001]). At least two commercial incinerators are licensed to treat P4 in 55 gallon drums; no commercial incinerator has been identified which would accept P4-contaminated soils in bulk. Relative to the FMC Plant Site wastes, radionuclides and metals would be concentrated in the incinerator ash and would require S/S before disposal. There are no in-situ incineration technologies due to the high heat requirements.

3.5.1 Incineration Treatment Process

Incineration is a thermal process where soil, sludge and other wastes are treated at high temperatures (1,400 to 2200°F) in a kiln, often a rotary kiln, to volatilize and combust contaminants. Incinerators typically are constructed using primary and secondary combustion chambers. They also use a variety of off-gas treatment processes and equipment, including filtration, wet-scrubbers, electrostatic precipitators, baghouses, vapor-phase carbon adsorption, and thermal oxidation.

Incineration would reduce the concentration of elemental phosphorus and volume in soil. Elemental phosphorus would be oxidized and natural organic matter in the soil would be converted to carbon dioxide. Oxidized elemental phosphorus would be captured by off-gas treatment systems such as scrubbers and treated further or discharged as a by-product. Most of the heavy metals and radionuclides would not be oxidized and would be concentrated in the residual ash.

3.5.2 Complete Incineration Process Treatment Sequence

The complete incineration treatment sequence would be a complex process operation that would involve the excavation (or wet dredging) of the P4-impacted material and transport of the material to the treatment location either on- or off-site. If conducted on-site, the treatment train also would require storage of the excavated material to provide feed surge to the treatment process, sizing (e.g., crushing and screening) of the material to provide a consistent feed particle size to the treatment process, incineration, treatment of ash for metals and radionuclides, transportation to the final disposal site, and landfill disposal.

3.5.3 Engineering Challenges/Issues for Incineration

The following discussions provide a preliminary analysis of the engineering challenges and issues if incineration were applied to P4-impacted soils.

3.5.3.1 On-Site Incineration Treatment As Applied to P4-Impacted Soils

Ancillary process options associated with incineration ex-situ treatment: If on-site incineration treatment were performed on P4-contaminated soil, the ancillary process options (and associated engineering challenges/issues) would include the following:

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2);
- Excavated soil transport and storage (see Section 2.2.1.3);
- Treatment feed sizing (see Section 2.2.1.4); and
- Treatment feed sampling and blending (see Section 2.2.1.5).

Incineration: If conducted on-site, the incineration treatment process itself would present some significant engineering challenges, even with a consistent feed particle size and P4 concentration. The soils at the site would most likely have a low BTU value and therefore would require large amounts of fuel. Further, assuming that on site incineration would be based on bulk feed; the water in the slurried feed would also consume excess energy to combust. In addition, the elevated concentrations of inorganic contaminants and minerals in the soil may result in slagging, which would be retained in the incinerator ash and reduce output (EPA, 1998a). Incineration would result in the volatilization of some metals and the generation of PH_3 gas. These gas streams would require treatment by an off-gas treatment system involving a scrubber. Before the incinerator could be operated at full scale, a trial burn would be necessary to optimize

the treatment process and ensure that emissions and operating conditions were consistent with those specified under applicable permit programs.

3.5.3.2 Off-Site (Commercial) Incineration Treatment As Applied to P4-Impacted Soils

Ancillary process options associated with incineration ex-situ treatment: If off-site incineration treatment were performed on P4-contaminated soil, the engineering considerations would be more limited because several of the processes necessary for on-site incineration would be conducted by the commercial incinerator. Ancillary process options (and associated engineering challenges/issues) nevertheless would still exist with off-site incineration, specifically those associated with material handling:

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2); and
- Excavated soil transport and storage (see Section 2.2.1.3). However, storage requirements might be reduced by placing soils directly in 55-gallon barrels using the proper precautions (i.e., nitrogen blanket, cooling of the containers, use of water, etc.) to eliminate spontaneous combustion of P4. An additional issue associated with this option would be public safety concerns from transportation of many loads P4-contaminated soils to the selected off-site commercial incinerator.

The commercial off-site incinerator would be responsible for these other necessary processes steps including:

- Treatment feed sampling and blending (see Section 2.2.1.5); and
- Ash S/S and disposal.

Incineration: For off-site incineration, issues surrounding the required sizing and physical composition of the feed stream, P4 concentration in the feed stock, BTU value of the feed stock, gas and wastewater treatment systems (i.e., air scrubber and waste water treatment plant [WWTP]), and ash disposal would be the responsibility of the commercial incinerator.

3.5.4 Incineration Treatment Performance and Limitations

Given the engineering challenges and issues associated with incineration, the following limitations, advantages, and potential applications are identified for P_4-contaminated soils at the FMC Plant Site:

Limitations:

- Generally not applicable for soil depth over 15 feet due to limitations of excavation equipment.

- High energy requirements.
- Requires obtaining air permit if conducted on-site.
- Does not treat all metals and radionuclides, which instead are concentrated in the ash.
- Some metals would be volatilized, requiring those volatiles and gases from the P4 reaction processes to be removed by an air scrubber connected to the rotary kiln.
- High cost and, for on-site incineration, extended time required for design, construction, trial burns and demonstration of compliance with operational and emission requirements under applicable permit programs.

Advantages:

- Robust technology that can handle larger variations in P4 concentrations.
- Significant variation in soil particle size may not prevent processing.
- Commercially available with necessary permits.

Potential Applicability:

- Soils with wide range of P4 concentrations.

3.5.5 By-Products and Residuals

In any treatment process, the by-products and residuals must be addressed in the feasibility evaluation and cost. The following by-products and residuals would be expected from the incineration treatment process:

- Off-gases consisting of P_2O_5, phosphine, and some metals, which would require further treatment;
- Ash, potentially containing concentrated levels of metals and radionuclides that would requiring further treatment before disposal; and
- Wastewater from scrubber and waste dewatering would require WWTP. Sludges from the WWTP likely would contain metals and radionuclides that would require further treatment prior to disposal.

3.5.6 History of Use

Commercial incinerators are available for treating P4-contaminated soils. During the FMC Plant decommissioning from 2002 to 2006, offsite incineration was used for disposal of residual P4 removed from process tanks, sumps and aboveground piping and for a limited amount of P4-contaminated equipment that could not be effectively cleaned (e.g., small diameter heat transfer coils) and that could be reduced in dimensions to fit into 55-gallon drums.

A full-scale incinerator has been developed for P4 in munitions at the Crane Army Ammunition Activity (CAAA), in Crane, Indiana. The facility is referred to as the WP to Phosphoric Acid Conversion (WP-PAC). The furnace was designed to treat small quantities of elemental phosphorus contained in bombs. At the WP-PAC facility, a hole is punched in ordinance using a 115 ton hydraulic press at ambient temperatures, exposing the WP in the ordinance to oxygen. The ordinance items are then pushed into the first section of a rotary kiln furnace to melt the WP, which flows out of the punched hole. The WP is then burned in an oxygen-rich furnace to form P_2O_5. At full-scale level since 1989, the facility at maximum capacity can process up to 11,500 pounds of WP, which is extracted from munitions, per day. In a 24-hour period, the facility produces 48,000 pounds of phosphoric acid with 75% concentration (http://www.crane.army.mil/caaa/WhitePhosphorus/WhitePhosphorus_pg.htm). Information was not provided regarding the current status of the WP-PAC facility and whether it might be available for use by commercial companies such as P4 manufacturers (EPA, 2003).

3.6 THERMAL DESORPTION

Thermal desorption is much like the incineration process in that it uses heat to volatilize (oxidize) the COCs. However the temperatures in the rotary furnace under this process are much lower (on the order of 200 to 600°F instead of 1,400 to 2,200°F). Thermal desorption is used to treat soil and sludge by heating (directly or indirectly) to volatize contaminants and separate them from the solid matrix without combustion. Radionuclides and metals would be concentrated in the solid residues of the treatment unit and would require S/S before disposal. There are no in-situ incineration technologies due to the high heat requirements. Thermal desorption is considered only as an ex-situ treatment technology.

3.6.1 Thermal Desorption Treatment Process

The common configuration for the thermal desorption process includes a rotary kiln, thermal screw, or infrared (IR) exposure. With IR treatment, the contaminated soil/sludge is typically placed in 5 cubic yard trays for processing. The rotary kiln and thermal screw operate on a continuous basis, with heat applied by combustion of natural gas, while the IR system is a batch process (EPA, 2003). The temperatures used in a thermal desorber are lower than in an incinerator, generally on the order of 200 to 600 °F. The volatilized contaminants (vapors) are collected and generally treated by one or more off-gas treatment technologies. Off-gas treatment equipment might include filtration, wet scrubbers, electrostatic precipitators, baghouses, vapor-phase carbon adsorption, and thermal oxidation. Thermal desorption would reduce the concentrations of P4 through volatilization. The P4 vapors would be recovered by treatment of the off-gas.

3.6.2 Complete Thermal Desorption Process Treatment Sequence

The complete thermal desorption treatment sequence would be a complex operation involving: 1) the excavation (or wet dredging) of the P4-impacted material, 2) transport of the material to the treatment location, 3) storage of the excavated material to provide feed surge to the treatment process, 4) sizing (e.g., crushing and screening) of the material to provide a consistent feed particle size to the treatment process, 5) sampling and blending with other extracted streams or inert materials of the feed to provide consistent P4 content, 6) thermal desorption treatment, 7) treatment of the solid residues from the process, 8) transportation to the final disposal site, and 9) landfill disposal.

3.6.3 Engineering Challenges/Issues for Thermal Desorption

The following discussions provide a preliminary analysis of the engineering challenges and issues if thermal desorption were applied to P4-impacted soils.

3.6.3.1 Thermal Desorption Treatment As Applied to P4-Impacted Soils

Ancillary process options associated with thermal desorption treatment: If thermal desorption treatment were performed for P4-impacted materials, the ancillary process options (and associated engineering challenges/issues) would include the following:

- Conventional excavation of soils (see Section 2.2.1.1);
- Wet dredging/hydraulic pumping excavation of soils (see Section 2.2.1.2);
- Excavated soil transport and storage (see Section 2.2.1.3);
- Treatment feed sizing (see Section 2.2.1.4); and
- Treatment feed sampling and blending (see Section 2.2.1.5).

Thermal Desorption Treatment: The treatment process would present some significant engineering challenges, even with a consistent feed particle size and P4 concentration. Operational concerns include the quantity of fuel needed to sustain desorption, and possible fire and explosion hazards. The soils at the FMC Plant Site have relatively low BTU values; therefore, thermal desorption would likely require significant consumption of fuel in order to reach and maintain treatment temperatures (EPA, 2003). Further, bulk feed stock would be wetted or in a slurry form, further increasing energy requirements to evaporate the water. Hot spots of WP contamination also present a safety hazard due to the possibility of spontaneously combusting during the thermal desorption process. In addition, the solid residue from the process would require further treatment for metals and radionuclides.

3.6.4 Thermal Desorption Treatment Performance and Limitations

Given the engineering challenges and issues associated with thermal desorption, the following limitations, advantages, and potential applications are identified for P_4- contaminated soils at the FMC Plant Site:

Limitations:

- Generally not applicable for soil depth over 15 feet due to limits of excavation equipment.
- High energy requirements.
- Might have difficulties treating highly-concentrated P4 (explosions) as might be found in many of the site soils.
- Requires obtaining air permit and time necessary to demonstrate and achieve compliance with operational and emission requirements under applicable permit programs.
- Does not treat metals and radionuclides.

Advantages:

- Lower energy requirements than incineration.
- Lower treatment temperatures would limit or eliminate the volatilization of metals that occurs during incineration.

Potential applicability:

- Soils with a relatively wide range of P4 concentrations.

3.6.5 By-Products and Residuals

In any treatment process, the by-products and residuals must be addressed in the feasibility evaluation including the cost analysis. The following by-products and residuals would be expected from the thermal desorption treatment process:

- Off-gases consisting of P_2O_5, phosphine, and some metals that might be volatilized would require further treatment;
- Wastewater from scrubber and waste dewatering (if applicable) would require WWTP. Sludges from the WWTP likely would contain metals and radionuclides that would require further treatment prior to disposal; and
- Solid residue from the process would contain concentrated levels of metals and radionuclides that would require further treatment before disposal.

3.6.6 History of Use

This process has been used at full scale for the volatilization of P4. As described in EPA's *2003 Treatment Technologies Report*, the USACE reported that a patented infrared system, operating on a batch basis, was used to treat 300 tons of WP-contaminated soil in DDOU. The treatment system was provided by ENSR (fka McLaren-Hart Environmental Engineering Corporation). The treatment rates for this system were reported to average 1 hr and 40 minutes for each 5 yd^3 batch, for a total treatment time for the 300 tons of 4 days. Assuming a similar treatment time it would take approximately 30 years to treat all of the impacted soils in RUs 1, 2, and 22b using a similar process. The USACE reported that one instance of auto-ignition of P4 was detected inside the desorber, which was controlled. Information was not provided specifying the concentrations of WP or other contaminants in the soil before or after treatment, or about the disposition of treatment residuals (USACE, 1996). It is assumed that the technology was used to treat relatively low concentrations of P4 in soils as is typically found in military sites, e.g., <1,000 ppm P4. ENSR personnel were not familiar with the current availability of the infrared desorption unit (Stewart, 2001).

Section 4.0 Elemental Phosphorus Treatment Technologies – Groundwater

This section presents an overview of the technologies that were identified and screened for treatment of elemental phosphorus-contaminated groundwater at the FMC Plant OU.

As described in the Groundwater Current Conditions Report for the FMC Plant OU, the primary site-related groundwater COC is arsenic and the extent of site-related groundwater impacts can effectively be delineated by arsenic concentrations above the representative concentration. Within the overall area of arsenic-impacted groundwater, site-related groundwater COCs include metals (e.g., manganese, selenium and vanadium), nutrients (primarily total phosphorus in orthophosphate form and nitrogen primarily as nitrate), fluoride, total cyanide and elemental phosphorus. The SFS Report will present the identification and screening of technologies for groundwater based on the full suite of groundwater COCs. Remedial technologies for the overall site-impacted groundwater will be identified, screened and evaluated in the SFS Report for the FMC Plant OU.

This section focuses on technologies that may be effective for treatment of P4 in groundwater that has been detected downgradient from RUs 1 and 2, specifically at wells 108 and 122. The groundwater P4 remedial technologies may or may not be effective for the treatment of other groundwater COCs.

Several process options / technologies have been identified that will be evaluated as options and/or as components of an overall groundwater remedial alternative for the site. These options will not be discussed here because they would not likely be applied solely to P4-containing groundwater:

- Deed (Groundwater Use) Restrictions
- Groundwater Monitoring
- Source controls
- Cut-off (e.g., slurry or grout) walls

The ancillary process steps associated with the in-situ and ex-situ technologies that may represent treatment options for site-impacted groundwater, including P4-containing groundwater, are not discussed in detail in this section. The ancillary process steps associated with in-situ technologies relate to the injection wells and systems necessary for addition (e.g., injection) of physical and/or chemical agents directly into groundwater. Ex-situ technologies require additional process steps such as groundwater extraction (pumping), either for hydraulic control or for mass removal, storage prior to and potentially after the treatment process, and use/disposal of the treated water. These ancillary process steps will be evaluated in the SFS Report but are not discussed below because these steps are not unique to treatment of P4-containing groundwater.

The following technologies have been identified for potential treatment of P4-containing groundwater:

- Oxidation – Chemical or physical oxidation could be effective as an ex-situ and in-situ treatment technology for dissolved-phase P4-containing groundwater.

- Hydrolysis – Chemical hydrolysis could be effective as an ex-situ treatment technology for dissolved and particle-phase P4-containing groundwater.

- Reverse osmosis – Reverse osmosis could be effective as an ex-situ treatment technology for dissolved and particle-phase P4-containing groundwater.

A screening-level evaluation of treatment technologies for P4-containing groundwater is presented below. For each technology identified, information is provided (to the extent known based upon literature research and FMC experience) on the following topics:

- Summary description of the technology and its potential applicability, ex-situ or in-situ, at the FMC Plant OU, and

- Preliminary evaluation of the effectiveness of the technology and potential engineering and operational challenges associated with implementation.

4.1 Oxidation

4.1.1 Summary Technology Description

Ex-situ or in-situ oxidation technologies involve the addition of chemical oxidants, ultraviolet light (UV), ozonation and/or mechanical addition of oxygen (air) to the aqueous solutions to promote oxidation of reduced inorganic elements or to create an oxidizing reaction with organic compounds. Chemical oxidants for treatment of aqueous solutions include the following:

- Hydrogen peroxide
- Potassium permanganate
- Calcium hypochlorite
- Persulfate (Potassium, sodium, ammonium)

Physical oxidation involves the use of UV light irradiation and/or introduction of oxygen, ozone or air by diffusion (e.g., sparging) into the aqueous solution.

As described in the Groundwater Current Conditions Report for the FMC OU, elemental phosphorus is detected in groundwater at wells 108 and 122 downgradient from RUs 1 and 2, but not at wells 111, 146 and 110 that are further downgradient from wells 108 and 122. Although the reduction in P4 concentrations could be due in part to advective mixing, oxidation and hydrolysis of P4 in groundwater are likely the primary mechanisms whereby the P4 is converted to phosphorus compounds (e.g., orthophosphate) as groundwater migrates downgradient from

these wells. Chemical or physical oxidation would be utilized to accelerate (increase the rate) of natural oxidation of P4 in water.

Ex-situ treatment would involve extracting (pumping) groundwater and routing the water to a storage tank(s) and then feeding the water into a reactor tank(s) where the selected oxidizing chemical(s) would be added and/or physical oxidation would be performed.

In-situ treatment would involve injection of the selected oxidizing chemical(s) and/or use of physical oxidation techniques within groundwater wells located to effectively deliver the oxidant within the zone of P4-contining groundwater.

4.1.2 Preliminary Evaluation of Effectiveness

Laboratory testing, pilot-scale and/or full scale application of chemical and/or physical oxidation technologies found from the literature and information search is focused on treatment of P4 production waste streams (e.g., phossy water and P4 sludge). The literature indicates chemical and/or physical oxidation (including wet air oxidation) are not very effective for treating solid phase P4 (either as particles, particle-sorbed or as a P4/water emulsion).

The technology identification search did not reveal any information specific to the testing of oxidation technologies on relatively low concentrations of dissolved P4 in water (i.e., water with P4 concentrations less than the solubility limit of 3 mg/l). However, based on the literature and research into the fate of P4 in aqueous systems, oxidation would be expected to be effective for accelerating the natural oxidation of P4 in water and conversion of the P4 to oxidized phosphorus compounds (e.g., orthophosphate).

Chemical/physical oxidation for treatment of P4 would also oxidize metals (e.g., As^{+3} to As^{+5}) and nutrients (e.g., ammonia to nitrate) and potentially make these groundwater COCs more amenable to treatment using other technologies. However, oxidation would not be effective as a stand-alone overall groundwater treatment technology. This limits its potential utility as an in-situ technology. In addition, adequate delivery and mixing of the oxidant into groundwater could be difficult to implement.

4.2 Hydrolysis

4.2.1 Summary Technology Description

Hydrolysis is a chemical reaction during which water molecules are split into hydrogen and hydroxide ions, which may go on to participate in further reactions. Generally, strong acids or bases must be added to achieve hydrolysis. The acid or base is considered a catalyst and aid in increasing the rate of the reaction.

As described in the Groundwater Current Conditions Report for the FMC Plant OU, elemental phosphorus is detected in groundwater at wells 108 and 122 downgradient from RUs 1 and 2, but not at wells 111, 146 and 110 that are further downgradient from wells 108 and 122. Although the reduction in P4 concentrations could be due in part to advective mixing, oxidation and hydrolysis of P4 in groundwater are likely the primary mechanisms whereby the P4 is converted

to phosphorus compounds (e.g., orthophosphate) as groundwater migrates downgradient from these wells. Chemical catalyzed hydrolyses would be utilized to accelerate (increase the rate) of natural hydrolysis of P4 in water.

Ex-situ treatment would involve extracting (pumping) groundwater and routing the water to a storage tank(s) and then feeding the water into a reactor tank(s) where the selected acid- or base-catalyzed hydrolysis would be performed.

In-situ chemical catalyzed hydrolysis would involve injection of the selected acid/base within groundwater wells located to effectively deliver the reagent within the zone of P4-contining groundwater.

4.2.2 Preliminary Evaluation of Effectiveness

Laboratory testing, pilot-scale and/or full scale application of base (caustic) catalyzed hydrolysis technologies found from the literature and information search is focused on treatment of P4 production waste streams (e.g., precipitator slurry and phossy water). The literature indicates that caustic hydrolysis is effective for treating wastewater and non-wastewater wastes (e.g., phossy water and precipitator slurry) containing P4 concentrations in the range of 1 to 2 percent.

The technology identification search did not reveal any information specific to the testing of hydrolysis technologies on relatively low concentrations of dissolved P4 in water (i.e., water with P4 concentrations less than the solubility limit of 3 mg/l as observed in wells 108 and 122). However, based on the literature and research into the fate of P4 in aqueous systems, chemical-catalyzed hydrolysis would be expected to be effective for accelerating the natural hydrolysis of P4 in water and converting the P4 to phosphorus compounds (e.g., phosphorus acids and phosphine).

Chemical-catalyzed hydrolysis treatment of P4 would not be effective for treatment of other groundwater COCs. However, the use of lime (calcium oxide) or slaked lime (calcium hydroxide) for catalyzed caustic hydrolysis would also be expected to precipitate other cations and anions. Precipitation, in conjunction with filtration technology, will be evaluated as a remedial technology the overall groundwater remedy.

In-situ hydrolysis of P4-containing groundwater would have similar challenges to chemical/physical oxidation, i.e., effective delivery and coverage. It also would have the negative effect of adding salts (TDS) to the groundwater system.

4.3 Reverse Osmosis

4.3.1 Summary Technology Description

Reverse osmosis is physical treatment process in which pressurized water passes through a semi-permeable membrane. The applied pressure to the waste stream is greater than the osmotic pressure of the feedwater. As water passes through the membrane, dissolved constituents in the water are concentrated on the feed side of the membrane to form the waste brine and a purer, more dilute product water is formed on the permeate side of the membrane. Depending upon the

feedwater concentrations, the waste brine may be as much as 15-percent to 25-percent of the total feedwater flow. The brine would require further handling and/or treatment prior to disposal.

Ex-situ treatment would involve extracting (pumping) groundwater and routing the water to a storage tank(s) and then feeding the water into a reverse osmosis system(s). Reverse osmosis is not applicable as an in-situ technology.

4.3.2 Preliminary Evaluation of Effectiveness

The technology identification search did not reveal any information specific to the testing of reverse osmosis technologies on dissolved P4 in water (i.e., water with P4 concentrations less than the solubility limit of 3 mg/l). However, based on literature and research of reverse osmosis, the technology would be effective at removing dissolved constituents (including P4) from site groundwater. However, reverse osmosis produces a concentrated brine stream that would likely require further treatment prior to disposal. In addition, reverse osmosis has high energy requirements and the waste brine would require pretreatment, making it much more costly than other effective ex-situ treatment technologies.

Section 5.0 Findings

This report provides a summary and evaluation of available information regarding "active" or "intrusive" remedial technologies, both in-situ and ex-situ, that have the potential to treat soils (including fill materials) and groundwater at areas within the FMC Plant OU that are known or suspected to have P4 contamination. The approach taken here regarding the identification and evaluation of potential treatment technologies is similar to that taken by the EPA Office of Solid Waste and Emergency Response in its 2003 report entitled "*Treatment Technologies for Historical Ponds Containing Elemental Phosphorus – Summary and Evaluation.*" While this report focuses on treatment technologies, it is recognized that the SFS Report will also evaluate all remediation technologies that potentially could treat all the site COCs, including heavy metals, radionuclides (including gamma), and organics in addition to P4, where those COCs are detected in soils and groundwater above RAOs.

This section is organized into two subsections. The first subsection (Section 5.1) summarizes the findings of EPA's *2003 Treatment Technologies Report* referenced above, and updates those findings to reflect developments since the date of that report and the evaluations presented here. The second subsection (Section 5.2) presents the general findings of this report and lists for reference, the remedial technologies that this report has identified and evaluated. Both subsections discuss the relevant findings of the *SRI Report* to specifically evaluate the technologies against the actual conditions at the site including the potential application of these technologies to the Remedial Units containing P4 in the FMC Plant OU.

5.1 UPDATES TO THE OVERALL FINDINGS OF EPA'S 2003 *TREATMENT TECHNOLOGIES REPORT*

EPA's 2003 *Treatment Technologies Report* was specifically focused on treatment of P4-containing sludges within ponds at the FMC Plant Site. Thus it is worthwhile to re-examine the general findings of that report.

Six technologies were identified in the *2003 Treatment Technologies Report* as potentially applicable: solidification/stabilization (S/S); caustic hydrolysis; chemical oxidation; mechanical aeration; incineration; and thermal desorption. The following is a summary, discussion and update of the key findings in that report.

EPA Report Finding No. 1: No technology has been used at full-scale to treat waste material similar to that found at the FMC Plant Site.

Summary of EPA finding No. 1: *Only limited information is available in the literature covering the remediation of WP, with fewer than 10 studies identified that discuss the potential use of treatment technologies for WP. This primarily includes studies performed at WP manufacturing facilities and at military facilities. While technologies have been used to treat WP in bench- and pilot-scale studies, no technologies were identified as having been used for full-scale treatment.*

Current Update to EPA Finding No. 1: Based upon the review of internal FMC technical documents related to P4, discussions with personnel at other P4 manufacturing facilities, review

of technical information from these sources related to P4 treatment, and search of the Internet for technical documents related to P4 treatment, there have been no significant developments in P4 treatment technologies since 2003.

EPA Report Finding No. 2: No new treatment technologies have emerged as potentially applicable since the EMF Feasibility Study.

*Summary of EPA Finding No. 2**:** The six technologies in the 2003 EPA report had been identified in the Feasibility Study for the FMC Subarea prepared in 1996.*

Current Update to EPA Finding No. 2: Again, no new treatment technologies have emerged as potentially applicable to the FMC Plant Site.

EPA Report Finding No. 3: Other WP manufacturing facilities primarily used capping as the remedy for similar waste.

*Summary of EPA Finding No. 3**:** Eight other WP manufacturing sites were identified that have similar contaminated historical ponds as those at the FMC Plant OU. Six of the eight sites have installed or plan to install caps. For the two remaining sites, one (Rhodia, located at Silver Bow, Montana) indicated that the ponds are not under corrective action or closure programs that would require capping, and the other (Stauffer, located at Tarpon Springs, Florida) is evaluating a remedy of in situ S/S.*

Current Update to EPA Finding No. 3: EPA's finding regarding the WP manufacturing sites that have installed or plan to install caps as soil/solid waste remedies remains valid, although additional WP sites have been identified where the final remedy also has included capping / containment. Updates regarding the Rhodia-Silver Bow and Stauffer-Tarpon Springs sites are provided below.

The Rhodia, Inc. phosphorus manufacturing facility in Silver Bow, Montana is currently evaluating treatment technology for waste in a process clarifier consisting of solidified, phosphorus-rich (20%) sludge. Rhodia is conducting this evaluation under the RCRA corrective action program. The clarifier is 100 feet in diameter, 12 feet deep, open-topped, with reinforced concrete walls and base. It contains 8 to 9 feet of phosphorus-rich waste, covered by more than 2 feet of water. To date, this evaluation has not yielded a selected corrective action.

The Stauffer site in Tarpon Springs, Florida completed a treatability study after the 2003 EPA Report that evaluated in-situ S/S. In-situ S/S has since been rejected as not being viable and a capping remedy has been selected. See the June 2007 Explanation of Significant Differences for this site and discussion below.

EPA Report Finding No. 3: Minimal performance data currently exist for use of the six technologies to treat similar waste material as found at EMF.

*Summary of EPA finding No. 3**:** Performance data were identified for treatment of WP using chemical oxidation, mechanical aeration, and incineration. However, these data are not for treatment of wastes in historical ponds at a WP manufacturing facility. Performance data for*

chemical oxidation and mechanical aeration are for work at bench- and pilot-scale, while data for incineration are for ordnance wastes with a higher percentage of WP than found in the FMC historical ponds. Thermal desorption was used for the treatment of WP in contaminated soil. Recent attempts to obtain specific information on the project revealed that the technology vendor was sold to another company. Personnel at this company were not familiar with the current availability of the technology. Therefore, it is unknown if the WP-contaminated soil was similar to waste material as found at the FMC Plant OU and no specific performance data were available for review. No performance data were identified for treatment of WP using S/S and caustic hydrolysis. Both technologies have been considered for the treatment of similar waste material at WP manufacturing sites.

The Stauffer site in Tarpon Springs, Florida is planning to test in situ S/S in 2003. Although the information from this test program could be used to evaluate the effectiveness of S/S at the FMC Plant OU, the test program at Tarpon Springs may not be an accurate predictor of performance for the FMC Plant OU waste. Reasons for this include: the type of phosphate ore used at Tarpon Springs is different from that used at EMF, elemental phosphorus is not a primary contaminant at Tarpon Springs, and the scale of the Tarpon Springs site is smaller. Caustic hydrolysis was considered for use at the Rhodia site in Silver Bow, Montana. In addition, caustic hydrolysis was identified as the Land Disposal Restrictions treatment technology for process waste streams from the FMC plant, but construction of that treatment system was halted with the plant shutdown.

Current Update to EPA Finding No. 3: In February 2006, Stauffer initiated the field-scale studies for in-situ solidification and stabilization within Pond 48. As a result of the cement curing, the elemental phosphorous ignited and created a persistent fire. The Field Scale study was discontinued due to the fire, resulting phosphorus gas generation, and uncertainty regarding the potential locations of buried elemental phosphorous that could create additional fires. In May 2007, a modified remedy was selected consisting of the construction of a groundwater cut-off wall and cap as a replacement for the planned in-situ stabilization remedy.

EPA Report Finding No. 4: Additional testing would be necessary to assess whether treatment technologies could perform adequately across a range of contaminant concentrations and properties of the waste material as found at EMF.

*Summary of EPA finding No. 4**:** Limited site characterization data are available and the historical ponds are assumed to be heterogeneous in physical and chemical composition. Therefore, extensive site assessment and treatability testing would be needed to verify the potential for any technology to treat the soil and sludge at the FMC Plant OU. Treatability tests would include evaluating how the technology would perform for the specific matrices in the different ponds, and the variations in performance across the range of concentrations and physical properties.*

Although the six technologies are at various stages of commercial development, the technologies would all require testing to establish that they could perform reliably for the waste material in the historical ponds. S/S, chemical oxidation, incineration, and thermal desorption have been applied commercially at full-scale for site remediation, but have not been used to treat WP pond material. Caustic hydrolysis and mechanical aeration have not been used extensively for site

remediation, and significant developmental testing would be required for scale-up along with treatability testing. Developmental and treatability testing for the six technologies would require additional time and resources to undertake.

Current Update to EPA Finding No. 4: No additional input to this finding.

EPA Report Finding No. 5: A series of technologies may be necessary to collectively treat all the types of contaminants.

*Summary of EPA finding No. 5**:** The soil and sludge in the historical ponds contain multiple types of contaminants that all may require treatment. For example, incineration, thermal desorption, mechanical aeration, and chemical oxidation show potential to treat WP, but would not be able to treat heavy metals or radionuclides. In these cases, an additional treatment process would likely be needed, such as S/S, using what is often referred to as a "treatment train."*

Current Update to EPA finding No. 5: No additional input to this finding.

EPA Report Finding No 6: Of the six technologies, only S/S and caustic hydrolysis have the potential to be effective for treatment of heavy metals and radionuclides.

*Summary of EPA finding No. 6**:** S/S is applied frequently at full-scale to reduce the mobility of heavy metals (radionuclides are expected to behave in a manner similar to heavy metals) at contaminated sites. Caustic hydrolysis would convert heavy metals to metal oxides and hydroxides, which generally are less soluble than the metal compounds, and could be removed by filtration or settling processes.*

Current Update to EPA Finding No. 6: It is not clear that caustic hydrolysis would treat waste streams containing metals or radionuclides to levels that would not require further treatment. At a minimum, treatability studies would be necessary to evaluate effectiveness of caustic hydrolysis in treating all COCs at the site..

EPA Report Finding No 7: Residuals from treatment, such as solid, liquid, or gaseous materials, would require further management.

*Summary of EPA finding No 7**:** Residual management may include characterizing and transporting these residuals to a storage or disposal facility (on- or off-site), or performing further treatment (such as for off-gases) prior to release to the environment.*

Current Update to EPA finding No. 7: Management of residuals likely would have significant implementability and cost impacts, and could pose significant potential environmental, site worker safety and public safety issues. The remedial alternative evaluation including the cost analysis would have to consider the capital and O&M costs and other factors associated with implementing the measures that would be needed to manage residuals.

***<u>EPA Report Finding No 8:</u>* Soil and sludge may require pre-processing to homogenize the material for use by treatment technologies.**

*<u>Summary of EPA finding No. 8</u>**:** Pre-processing may include crushing, grinding, or milling, to break up large masses of soil and sludge. For both ex-situ and in-situ technologies, pre-processing may be necessary depending on the distribution of contaminants in the ponds and the methods used to implement the treatment technologies.*

<u>Current Update to EPA finding No. 8</u>: As discussed in this report, ancillary processes: 1) are integral to the overall remedial alternative, 2) present engineering challenges as difficult as the treatment process itself, 3) will have major cost impacts, and 4) pose significant potential environmental, site worker safety and public safety issues. The remedial action evaluation would need to consider the capital and O&M costs and other decisional criteria with respect to the measures that would be required to safely pre-process the soils, sludges, and fill materials before implementing treatment technologies.

***<u>EPA Report Finding No. 9:</u>* The estimated volume of waste material to treat (500,000 cubic yards) would entail a large remediation project, including significant engineering issues.**

*<u>Summary of EPA finding No. 9</u>**:** The physical layout of the site, where historical ponds are located near RCRA ponds, structures, and slag piles, may impact the implementation of a treatment technology, including the need for space to stage equipment or to store material before or after treatment.*

<u>Current Update to EPA Finding No. 9</u>: Based upon the current estimates for RUs 1, 2, 13, 22b, and 22c and areas with underground piping containing P4, the total volume of materials to be treated in areas impacted by P4 is estimated at 780,122 yd^3. The total amount of P4 within this volume is estimated to range from 5,050 to 16,380 tons.

***<u>EPA Report Finding No. 10:</u>* Site workers would need to follow stringent health and safety precautions for handling soil or sludge containing WP.**

*<u>Summary of EPA finding No. 10</u>**:** WP is an inorganic compound that ignites spontaneously in warm air. It is toxic by ingestion and inhalation, and skin contact with WP causes burns. Site workers would likely need to use Level C personal protective equipment (respiratory and skin contact protection) when conducting work on the soil or sludge in the historical ponds. In addition, health and safety precautions related to metals and radionuclides would also have to be considered.*

<u>Current Update to EPA Finding No. 10</u>: Although neither the EPA *2003 Treatment Technologies Report* nor this paper was intended as a full evaluation of the health and safety precautions necessary for site remediation workers, very stringent worker protection measures certainly would be required. It is clear that Level C PPE would not be sufficient or adequate to protect against thermal burn hazards and/or gas generation associated with P4 reactions (which could include PH_3). For any work inside enclosures where P4 gases were present, as discussed in Section 2.0, supplied air would be necessary (Level A PPE) in addition to aluminum gear to

prevent direct dermal exposure to P4. The remedial action evaluation would need to address the capital and O&M costs and other factors associated with the needed health and safety precautions, protections, and procedures.

EPA Report Finding No. 11: ***The cost to implement any of the six treatment technologies would be high, based on the criteria used to identify high cost projects by EPA's National Remedy Review Board (NRRB).***

*Summary of EPA finding No. 11**:*** *The NRRB identifies high cost remedial actions as those that cost more than $30 million, or more than $10 million and 50 percent greater in cost than the least costly cleanup alternative. Although the technology cost estimates in this report could be above or below the actual costs, the actual total treatment costs are likely to be higher. Specifically, the technology costs estimates do not include costs for associated project components, such as excavation (if required), preprocessing of waste material, health and safety (such as ambient gas control), and residual management, which could be integral parts of a remediation project at the FMC Plant OU using any of the six technologies.*

Current Update to EPA Finding No. 11: This paper did not review costs associated with these technologies and does not provide any additional input to this finding.

5.2 GENERAL FINDINGS P4 TREATMENT TECHNOLOGY SCREENING FOR FMC PLANT OPERABLE UNIT

The following are the general findings of this report:

- When screening and evaluating remedial technologies for P4-impacted materials, it is very important to consider the ancillary process options that would be necessary to complete the overall P4 treatment train. While some components of these ancillary process options have been used in other settings, none have been applied directly to materials representing a combination of P4/soil/fill materials like those present at the FMC Plant Site. Ancillary process options, especially those associated with ex-situ treatment, may present greater challenges for implementability than the treatment technology itself.

- Treatability studies for one or more of the ancillary and treatment processes likely would be required before categorizing any of the P4 treatment technologies as viable remedial options.

- EPA's 2003 *Treatment Technologies Report* appears to have been a complete and accurate evaluation of the availability of treatment technologies, the level of development, and the challenges of implementing a full-scale treatment system.

- Ex-situ oxidation or hydrolysis and in-situ oxidation have been identified as potentially effective treatment technologies for P4-containing groundwater although no specific information was found regarding the implementation of these technologies for P4-contaminated water at full scale.

The following is a brief summary of the P4 treatment technologies identified and evaluated in this report as applied to the types of soils and fill materials found at the FMC Plant OU.

5.2.1 Stabilization and Solidification (S/S)

S/S is potentially applicable, either in-situ or ex-situ, to areas with metals and radionuclides (but without P4 contamination) although would not likely be effective at addressing gamma. S/S might also be potentially applicable ex-situ to small volumes of shallow soils with low P4 impacts, e.g., soils around P4 piping that may have leaked, although likely not for the piping itself. S/S is likely not applicable for in-situ application for P4-impacted soils due to the inability to control mixing and reaction in variable P4 concentrations within the soils, similar to the experience at Tarpon Springs.

5.2.2 Mechanical Aeration

While aeration has been used successfully applied at a site where relatively shallow, low-concentration P4 exists in soils (Eagle River Flats), in-situ aeration or mechanical aeration is likely not applicable for P4-impacted soils at the FMC Plant OU due to the inherent safety risks of controlling P4 burning and gas generation rates in soils with highly, locally variable levels of P4 impact. Also, ex-situ mechanical aeration is likely not applicable due to lack of performance testing: even if excavation, feed material sizing, and blending challenges were overcome, alternative technologies have been identified as potentially more effective means to reduce P4 mobility and toxicity. Mechanical aeration also does not address radionuclides and metals and would require combination with other remedial technologies to address all co-located COCs.

5.2.3 Caustic Hydrolysis

Caustic hydrolysis is likely not applicable for in-situ application due to the inherent safety risks of controlling P4 burning and gas generation rates in soils with highly, locally variable levels of P4 impact. It may be applicable for ex-situ treatment of shallow P4 impacted soils where P4 concentrations are generally < 2 % in a matrix without significant amounts of larger particles (e.g., slag). Those parameters are necessary to provide some assurance of overcoming feed material sizing and blending challenges, above and beyond the excavation challenges that also would have to be met. To the extent that RU 13, 22b and 22c contain some portions of P4-impacted soils that meet these parameters, caustic hydrolysis, in combination with other technology (treatment or containment) for the generally much larger portion of those RUs where this technology would not be applicable, may warrant further evaluation. EPA (2003) indicates that caustic hydrolysis may convert some heavy metals present in process feed material (from site soils) to metal oxides and hydroxides. These metal oxides and hydroxides may not require additional treatment, although further testing would be required in this regard. The fate of radionuclides in the caustic hydrolysis process would also have to be determined.

5.2.4 Chemical Oxidation

Chemical oxidation is likely not applicable for in-situ application for P4-impacted soils due to the inherent safety risks of controlling gas generation rates in soils with highly, locally variable

levels of P4 impact. Chemical oxidation is also likely not applicable for ex-situ application due to lack of performance testing. This means that even if excavation, feed material sizing, and blending challenges were overcome, alternative technologies are potentially more effective in reducing P4 mobility and toxicity.

5.2.5 Incineration

Incineration is an ex-situ treatment technology only. Use of off-site incineration is potentially applicable to small volumes of shallow soils with low P4 impacts, e.g., soils around P4 piping that may have leaked. Off-site incineration is likely not applicable for large volumes due to transportation risks inherent with the total number of truck loads required and the packaging requirements (containers of 55 gallons or less). On-site incineration is likely not applicable due to the inability to treat other co-located COCs. Even if excavation, feed material sizing, and blending challenges were overcome, alternative technologies have been identified as potentially more effective means to reduce P4 mobility and toxicity as well as metals and radionuclides. On-site incineration also is likely not applicable due to the stringent permit design, environmental evaluation and operational requirements that would have to be met.

5.2.6 Thermal Desorption

Thermal desorption is an ex-situ treatment technology that is similar to incineration, but the treatment temperatures are much lower. Unlike offsite incineration, there are no known commercial offsite thermal desorption systems in operation so the system would have to be built on-site. Use of thermal desorption is potentially applicable to small volumes of shallow soils with low to moderate P4 impacts, e.g., soils around P4 piping that may have leaked. Thermal desorption is likely not applicable due to the inability to treat other co-located COCs (i.e., metal and radionuclides). Alternate technologies have been identified as potentially more effective means to reduce P4 mobility and toxicity as well as metals and radionuclides, again assuming that excavation, feed material sizing, and blending challenges could be overcome.

Table 5-1

Summary of Elemental Phosphorus Treatment Process Options

ELEMENTAL PHOSPHORUS TREATMENT TECHNOLOGIES - SOILS AND SOLIDS					
Process Option	**Process Description**	**Limitations**	**Safety During RA**		**History of Technology Field Use for P4 Contaminated Soils/Solids?**
			Remedial Site Worker	**Public**	
Removal Process Options					
Conventional Excavation	Excavation of contaminated soils using conventional earthworking equipment sized appropriately for the volume of material to be removed. Conventional excavation would be used to excavate the contaminated soil and transfer to other material handling steps prior to delivery to the treatment tecnology (process). With careful operation, soils containing phosphorus might be transferred with a water cover in the bucket to minimize mass burning, but there likely will be some level of smoking or fires from unintended, occasional spills or material above the water cover. Excess water in the excavation could result in mobilization of other COCs and potential groundwater impacts. Judicious water use may be better managed in small areas; risk of fire and/or excess water in the excavation would increase with the size of excavation area. Excavation might be combined with an enclosed temporary structure to minimize uncontolled release of P4 combustion products and exposure to other site workers or the public, but would also include air pollution control device for vented air and treatment and/or disposal of APC media.	• Depth of excavation, no greater than 15 feet below ground surface (bgs) • Handling of P4 soils would require addition of water to prevent combustion or temporary cover to capture phosphorus combustion offgases • Scrubber sludges would likely require treatment prior to disposal • PPE would require aluminum suit and possibly supplied air to prevent exposure to burning P4 (modified Level A)	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	During the construction of the LDR system, a small quantity of P4-contaminated soils were encountered. The P4-containing soils were excavated, containerized, and disposed off-site at an incinerator (the total quantity of excavated soil was less than 20 55-gallon drums).
Wet Dredging	Using a conventional dredge, wet materials would be excavated. Since the material is semi solid, it must be chopped up or melted into a slurry to allow pumping through a pipeline to the treatment process. For this process, solids are removed form the slurry with a complex treatment system, and the water is returned to the excavation site for reuse. This process was used by FMC in former phosphorus-laden ponds (i.e., phossy ponds). However, none of these semi-liquid phorphorus-bearing wastes remain at the site, and this process would require introduction of a significant volume of water to soils or solids (to create a slurry) that could result in mobilization of other COCs and potential groundwater impacts.	• Only dry P4 soils exist at the FMC Plant OU, would have to be flooded before process could work • Free water might transport soil COCs to the underlying groundwater	Low to moderate hazard during wet dredging and material handling of slurried solis/solids with widely varying P4 concentrations in the subsurface due to potential direct exposure (burns) and exposure to oxidation/reaction products.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	Yes. Wet dredging has been used in the past at the FMC facility to remove P4 contaminated sludges in active phossy ponds (during plant operations). However, none of these semi-liquid phosphorus-bearing wastes remain at the site and for this process to work water would have to be added to the ground surface without protection of the underlying groundwater. Note wet dredging has not been used at any P4 remediation sites to excavate dry materials.
Ex-Situ Treatment					
All ex-situ technologies would require the excavation or dredging of soil/solids and material handling steps: 1) transport within the site and 2) on-site storage. On-site ex-situ treatment technologies would also require the material handling steps: 1) sizing and blending of soil/solids to provide a uniform feed to the treatment process and 2) disposal of treated solids. Off-site ex-situ treatment (incineration) would also require the material handling steps: 1) containerization (and potentially sizing to enable contanerization) and 2) off-site transport.					
Stabilization/Solidification	Stabilization involves the addition of a cementious material that reacts with the contaminated soils to reduce the mobility of the contaminants. It is widely used for wastes containing metals prior to landfilling and in some cases Type C fly ash is used to replace or supplement Portland cement. The types of stabilization agents used depend on the chemical composition of the material being stabilized. Stabilization and solidification has been shown to be effective for reducing the leachability of heavy metals, however, its effectiveness for treating elemental phosphorus containing wastes and potential for unintended reactions during the curing process is not well understood.	• Generally not applicable for soil depth over 15 feet • Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b • Very complex complete treatment sequence • P4 associated with UG Piping could not easily be processed using S/S and • Significant variation in soil particle size and P4 concentration as found in most RUs would make the ex-situ handling process extremely complex.	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products. For ex situ treatment, handling necessary for feed material sizing and blending of spontaneously combustible material increases these risks.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	No. There is no history of laboratory or field testing has been identified for ex-situ S/S.
Mechanical Aeration	Mechanical aeration involves the use of physical equipment, such as a mixer to agitate a solid or slurry material and expose the material to the atmosphere where ambient oxygen would react with the elemental phosphorus contained in the solid matrix. The United States Army Corps. Of Engineers (USACE) indicated that a mechanical aeration system could be used ex-situ or in-situ to expose elemental phosphorus to oxygen. However, further studies would be required to determine how the degradation of elemental phosphorus is effected by concentrations of dissolved oxygen, mixing rate, matrix characteristics, depth of material, temperature, and pH.	• Generally not applicable for soil depth over 15 feet; • Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b; • Difficult to control of P4 reactions because of widely varying P4 concentrations. • Very complex complete treatment sequence (ex-situ); and • Significant variation in soil particle size and P4 concentration as found in most RUs containing P4 would make the ex-situ handling process extremely complex and difficult to operate and maintain. • Would not treat metals and radionuclides that are present in the P4-contaminated soils	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products. For ex situ treatment, handling necessary for feed material sizing and blending of spontaneously combustible material increases these risks.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	No. Has only been implemented in bench-scale studies. System has not been identified to effectively oxidize large amounts of soils with P4.

Table 5-1

Summary of Elemental Phosphorus Treatment Process Options

Caustic Hydrolysis	Caustic Hydrolysis is a chemical process where P4 reacts with lime and water at elevated temperature and pressure to form various phosphate compounds, as well as phosphine. This technology uses complex processing equipment operated by personnel with a relatively higher level of training. Key operating parameters include the amount of lime and water added, reaction pH, as well as the reactor temperature and pressure. Caustic hydrolysis would reduce the concentration of P4 and results in the generation of significant amounts of phosphine gas as a by-product that would require subsequent treatment. This technology would not be appropriate for metals or radionuclides.	• Generally not applicable for soil depth over 15 feet. • Very complex complete treatment sequence including all the ancillary treatment processes; • Difficult to supply consistent (size and concentration) P4 feed stream and therefore control P4 reactions. • Significant variation in soil particle size and P4 concentration as found in most RUs containing P4 would make the handling process extremely complex. • Requires additional treatment for radionuclides at a minimum, but possibly the metal oxides and hydroxides	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products. For ex situ treatment, handling necessary for feed material sizing and blending of spontaneously combustible material increases these risks.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	No, but has been used on slurried P4 production wastes. FMC used lime (caustic hydrolysis) treatment of precipitator slurry in the "slurry pots" during plant operation. Lime was used to treat a slurried process waste with low concentrations of P4 at GSHI facility in Columbia, TN. High concentrations of P4 have not been treated using this process. The LDR system formerly located at the FMC facility required a feed of slurried fine-grained process waste with low percentage of P4. The LDR systems was not completed; however it was not designed to handle feeds of varying P4 concentrations or high concentrations of P4. Designed feed rate would require an extremely long treatment time-frame for the amount of soil requiring treatment.
Chemical Oxidation	Chemical oxidation involves the addition of chemical agents to react with COCs in the soil to form oxidized by-products. Several types of ex-situ oxidation technologies have been identified to treat elemental phosphorus including nitric/sulfuric acid and oxygen (using high speed air dispersion (HSAD) process). The acid oxidation technology was developed and tested by the Tennessee Valley Authority (TVA) on sludge containing elemental phosphorus. The effluent from this process was then reacted with ammonia to produce a nitrogen and phosphate containing plant nutrient. Not effective for metals and rads, limited effectiveness for P4.	• Generally not applicable for soil depth over 15 feet • Very complex complete treatment sequence ; • Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b (both ex-situ and in-situ); • Difficult to control P4 reactions (in-situ and ex-situ) because of widely varying P4 concentrations; • Significant variation in soil particle size and P4 concentration as found in most RUs would make the process extremely complex and difficult to operate and maintain. • Does not treat metals and radionuclides associated with P4-contaminated soils and some processes even concentrate metals in the reactor sludges • Generation of phosphorus related gases that need to be treated and sludges disposed. • Liquid and solid process streams would need secondary treatment prior to disposal.	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products. For ex situ treatment, handling necessary for feed material sizing and blending of spontaneously combustible material increases these risks.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	No. However, it has been testing in the laboratory. Two types of ex-situ oxidation technologies have been identified to treat P4 including nitric/sulfuric acid and oxygen, using high speed air dispersion (HSAD) process. FMC and TVA have conducted tests in the laboratory using these processes with P4 sludge. Acid oxidation technology was developed by the TVA on sludge containing P4. However, homogenous application of chemical oxidation agents at the FMC plant OU may be extremely difficult in-situ due to the varying concentrations of P4 in the soil and the heterogeneous nature of the subsurface soil matrix.
Incineration	Incineration is a thermal process where soil, sludge and other wastes are treated at elevated temperatures (1,400 to 2200 °F) to volatilize and combust contaminants. Incineration would reduce the concentration of elemental phosphorus and volume in soil. Elemental phosphorus would be oxidized and natural organic matter in the soil would be converted to carbon dioxide. Oxidized elemental phosphorus would be captured by off-gas treatment systems such as scrubbers and treated further or discharged as a by-product. Heavy metals and radionuclides in the soil would not be oxidized and would mainly be concentrated in the residual ash from the incinerator. These ashes would require proper disposal.	• Generally not applicable for soil depth over 15 feet; • High energy requirements • Requires obtaining air permit (if conducted on-site). • Does not treat all metals and radionuclides (i.e., they are concentrated in the ash) • Some metals would be volatilized and these metals along with P4 reaction processes would have to be scrubbed from the air leaving the rotary kiln • Can only be shipped in 55 gallon containers for off-site commercial incinerator	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products. For ex situ treatment, handling necessary for feed material sizing and blending of spontaneously combustible material increases these risks.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	Yes. Off-site commercial incinerators are available and can handle widely varying concentrations of P4 but only in (up to 55-gallon) drums. The US Army has constructed and operated a facility at Crane Army Ammunition Activity (CAAA) to convert WP contained within ordnance to phosphoric acid using a rotary kiln furnace. On-site incineration would require construction of an incineration unit with ancillary feed preparation process(es) and air and wastewater treatment systems.
Thermal Desorption	Thermal Desorption is used to treat soil and sludge by heating (directly or indirectly) to volatize contaminants and separate them from the solid matrix without combustion. The temperatures used in a thermal desorber are lower than in an incinerator, generally on the order of 200 to 600 °F. The volatilized contaminants (vapors) are collected and generally are treated by one or more off-gas treatment technologies. Thermal desorption would reduce the concentrations of P4 through volatilization, and P4 vapors would be recovered by treatment of the off-gas. Thermal desorption would not reduce concentrations of heavy metals or radionuclides in the solids. The solids would require proper disposal with elevated metals and rads.	• Generally not applicable for soil depth over 15 feet; • High energy requirements • Might have difficulties treating highly concentrated P4 as might be found in many of the site soils (e.g., explosions); • Requires obtaining air permit; and • Does not treat metals and radionuclides	Moderate to high hazard associated with excavating and handling P4 in widely varying concentrations in the subsurface as of result of potential direct exposure (burns) and exposure to oxidation/reaction products. For ex situ treatment, handling necessary for feed material sizing and blending of spontaneously combustible material increases these risks.	Low to moderate hazard associated with removing soils with P4 due to potential release should significant oxidation occur.	Yes. Has been used on a limited basis in the field for a small quantity of P4 contaminated soils. A thermal desorption system was used for treatment of WP-contaminated soil in Ogden Utah. However, only 300-tons of material was processed and the concentration of P4 in the wastes was not disclosed.

Table 5-1

Summary of Elemental Phosphorus Treatment Process Options

In-Situ Treatment					
Stabilization/Solidification (S/S)	Stabilization/Solidification is a technology in which cementious material that reacts with the contaminated soils to reduce the solubility or mobility of the COCs. In-situ stabilization generally involves mechanical mixing of the solids in-place with stabilization agents. Various types of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types of stabilization agents used depend on the chemical composition of the material being stabilized.	• Generally not applicable for soil depth over 20 feet • Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b • Difficult to control P4 reactions because of widely varying P4 concentrations; • Difficult to get complete mixing in-situ • In-situ process would require no free water during treatment. Might result in contamination of underlying groundwater. • Liquid and solid process streams (air scrubber) would need secondary treatment prior to disposal.	Moderate to high hazard during intrusion into and reaction kinetics with soils/solids with widely varying P4 concentrations in the subsurface due to potential exposure to oxidation/reaction products.	Low to moderate risk from potential uncontolled releases due to exposure to oxidation/reaction products.	No. However, in-situ S/S was chosen at Tarpon Springs, Florida as the remedy for pond material and contaminated soil containing P4, heavy metals, and radionuclides. A brief pilot study at Tarpon Springs indicated that reactions of P4 with S/S additives were extremely violent and resulted in discontinuation of study. S/S has since been removed as remedy at Tarpon Springs and capping is the preferred alternative.
Mechanical Aeration	As described above in Ex-Situ treatment, mechanical aeration involves the use of physical equipment, in this case, such as a tiller to break up or agitate a solid material and expose the material to the atmosphere where ambient oxygen would react with (oxidize) elemental phosphorus contained in the solid matrix. The process would generate P4 oxidation/reaction off-gases during treatment that would need to be collected and treated.	• Generally not applicable for soil depth over 20 feet; • Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b; • Difficult to control of P4 reactions because of widely varying P4 concentrations. • Inadequate/incomplete mixing because of widely varying particle size. • Would not treat metals and radionuclides that are present in the P4-contaminated soils • Liquid and solid process streams (air scrubber) would need secondary treatment prior to disposal.	Moderate to high hazard during intrusion into and reaction kinetics with soils/solids with widely varying P4 concentrations in the subsurface due to potential exposure to oxidation/reaction products.	Low to moderate risk from potential uncontolled releases due to exposure to oxidation/reaction products.	No. No system has been identified to effectively oxidize large amounts of soils with P4 in-situ. Requires mechanical mixing or aeration equipment to provide continuous supply of ambient air/oxygen to the soils with P4. Aeration of P4 would likely generate hazardous off gases, such as phosphine, during treatment that would require collection and treatment.
Chemical Oxidation	Oxidation involves the addition of chemical agents through subsurface injection points to react oxidant with COCs in the soil to form oxidized by-products. Can be used with organics, but typically not used for inorganics.	• Generally not applicable for soil depth over 20 feet • Very complex complete treatment sequence ; • Generally not applicable for large volumes such as in RUs 1, 2, 13, or 22b; • Difficult to control P4 reactions (in-situ and ex-situ) because of widely varying P4 concentrations; • In-situ process would require no free liquids during processing. Might result in contamination of underlying groundwater. • Significant variation in soil particle size and P4 concentration as found in most RUs would make the process extremely complex and difficult to operate and maintain. • Generation of phosphorus related gases that need to be treated and sludges disposed. • Liquid and solid process streams (air scrubber) would need secondary treatment prior to disposal.	Moderate to high hazard during intrusion into and reaction kinetics with soils/solids with widely varying P4 concentrations in the subsurface due to potential exposure to oxidation/reaction products.	Low to moderate risk from potential uncontolled releases due to exposure to oxidation/reaction products.	No. Has only been implemented in bench-scale studies. No history of treatability studies on other sites containing P4 in soils. System has not been identified to effectively oxidize large amounts of soils with P4. Homogenous application of chemical oxidation agents at the FMC plant OU may be extremely difficult in-situ due to the varying concentrations of elemental phosphorus in the soil and the heterogeneous nature of the subsurface

ELEMENTAL PHOSPHORUS TREATMENT TECHNOLOGIES - GROUNDWATER					
Process Option	**Process Description**	**Limitations**	**Safety During RA**		**History of Technology Field Use for P4 Contaminated Groundwater?**
			Remedial Site Worker	**Public**	
Ex-Situ Treatment					
All ex-situ technologies require additional process steps including groundwater extraction (pumping), either for hydraulic control or for mass removal, storage prior to and potentially post treatment, and use/disposal of the treated water.					
Oxidation	Oxidation involves the addition of chemical oxidants, ultraviolet light (UV), ozonation and/or mechanical addition of oxygen (O3, O2 or air) to the aqueous solutions to promote oxidation of reduced inorganic elements or to create an oxidizing reaction with organic compounds.	Oxidation would not be effective for removal of other groundwater COCs.	Low to moderate hazard due to potential exposure to subsurface soils during installation of extraction wells. Low to moderate during system construction and O&M.	Low	No information was found specific to the testing or application of oxidation technologies on relatively low concentrations of dissolved P4 in water. Based on the literature and research into the fate of P4 in aqueous systems, oxidation would be expected to be effective for accelerating the natural oxidation of P4 in water and conversion of the P4 to oxidized phosphorus compounds (e.g., orthophosphate).
Hydrolysis	Hydrolysis generally involves the addition of a strong acid or base as a catylst to increase the hydrolysis reaction rate in aqueous solutions.	Hydrolysis would not be effective for removal of other groundwater COCs.	Low to moderate hazard due to potential exposure to subsurface soils during installation of extraction wells. Low to moderate during system construction and O&M.	Low	No information was found specific to the testing or application of hydrolysis technologies on relatively low concentrations of dissolved P4 in water. Based on the literature and research into the fate of P4 in aqueous systems, chemical-catalyzed hydrolysis would be expected to be effective for accelerating the natural hydrolysis of P4 in water.

Table 5-1

Summary of Elemental Phosphorus Treatment Process Options

Reverse Osmosis	Reverse osmosis is physical treatment process in which pressurized water passes through a semi-permeable membrane. The applied pressure to the waste stream is greater than the osmotic pressure of the feedwater. As water passes through the membrane, dissolved constituents in the water are concentrated on the feed side of the membrane to form the waste brine and a purer, more dilute product water is formed on the permeate side of the membrane.	Reverse osmosis produces a concentrated brine stream that would likely require further treatment prior to disposal. In addition, reverse osmosis has high energy requirements making it much more costly than other effective ex-situ treatment technologies.	Low to moderate hazard due to potential exposure to subsurface soils during installation of extraction wells. Low to moderate during system construction and O&M.	Low	No information was found specific to the testing or application of reverse osmosis on relatively low concentrations of dissolved P4 in water.
In-Situ Treatment					
Oxidation	Oxidation involves the injection of chemical oxidants and/or mechanical addition of oxygen (O3, O2 or air) to groundwater to promote oxidation of reduced inorganic elements or to create an oxidizing reaction with organic compounds.	Oxidation would not be effective for removal of other groundwater COCs and adequate delivery and mixing of the oxidant into groundwater could be difficult to implement.	Low to moderate hazard due to potential exposure to subsurface soils during installation of injection wells. Low to moderate during system construction and O&M.	Low	No information was found specific to the testing or application of oxidation technologies on relatively low concentrations of dissolved P4 in water. Based on the literature and research into the fate of P4 in aqueous systems, oxidation would be expected to be effective for accelerating the natural oxidation of P4 in water and conversion of the P4 to oxidized phosphorus compounds (e.g., orthophosphate).
Hydrolysis	Hydrolysis involves the injection of a strong acid or base as a catylst to increase the hydrolysis reaction rate in groundwater.	Hydrolysis would not be effective for removal of other groundwater COCs; adequate delivery and mixing of the acid/base catalyst into groundwater could be difficult to implement and would have the negative effect of adding salts (TDS) to the groundwater system.	Low to moderate hazard due to potential exposure to subsurface soils during installation of injection wells. Low to moderate during system construction and O&M.	Low	No information was found specific to the testing or application of hydrolysis technologies on relatively low concentrations of dissolved P4 in water. Based on the literature and research into the fate of P4 in aqueous systems, chemical-catalyzed hydrolysis would be expected to be effective for accelerating the natural hydrolysis of P4 in water.

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Marc Bowman

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Subject: SFS Memorandum - Buried Railcar Evaluations for the FMC Plant Operable Unit
Attachments: FMC Buried Railcar Rpt.pdf

Kira,

On behalf of FMC, I am submitting another deliverable in preparation for our meeting in Seattle on May 20th and 21st. Attached to this email as a pdf file is a SFS technology screening memorandum entitled *Buried Railcar Evaluations for the FMC Plant Operable Unit*.

Hard copies will follow.

Please call if you have questions or any difficulties opening this file.

Best Regards,

Vance Drain
801 617 3250 (direct line)

FMC Idaho LLC, Pocatello, Idaho

SFS Technology Screening Memorandum

Buried Railcar Evaluations
for the
FMC Plant Operable Unit

May 2009

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FIGURE 2.1 – Blow-Up of Area with Sludge-Filled Railcars at South End of Slag Pile

ATTACHMENT 1 - G.H. Scherbel Memo

ACRONYMS/ABBREVIATIONS

AOC	Administrative Order on Consent
BAPCO	Bannock Paving
CDC	Center for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	constituent of concern
CRREL	Cold Regions Research Engineering Laboratory
EMF	Eastern Michaud Flats
IRIS	Integrated Risk Information System
NPL	National Priorities List
OU	Operable Unit
POTW	publicly owned treatment works
RI/FS	Remedial Investigation/Feasibility Study
SFS	Supplemental Feasibility Study
SRI	Supplemental Remedial Investigation
SRI/SFS	Supplemental Remedial Investigation Feasibility Study
WWT	waste water treatment

SECTION 1.0 INTRODUCTION

1.1 OBJECTIVE AND SCOPE OF THIS REPORT

The Supplemental Feasibility Study (SFS) for the FMC Plant OU will present the identification, screening and evaluation of remedial technologies and alternatives for all of the COCs and media identified in the *Supplemental Remedial Investigation Report for the FMC Plant OU* (*SRI Report*; MWH, 2008). The SFS will include significant focus on options and technologies potentially effective to remediate elemental phosphorus (P4) in the subsurface and the unique P4 management risks associated with these options. This objective of this paper is to provide a summary of the evaluation and preliminary screening of removal/treatment options for addressing the railcars (RU 19c) buried in the slag pile (RU 19), both of which are included in Remediation Area F (RA-F). This paper is being submitted in advance of the SFS Report, to initiate discussion with EPA.

As described in *Identification and Evaluation of P4 Treatment Technologies – January 2009* (MWH, 2009), the excavation and treatment of any P4-impacted soil/fill presents significant challenges. The buried railcars, containing an estimated range of 200 to 2,000 tons of P4 sludge (depending on the amount of P4 in each railcar, as reported in Section 4.15.4 of the *SRI Report*), present a unique set of challenges, including:

- Depth of burial of the railcars;
- Accessibility with typical excavation equipment;
- Unknown condition of the railcars; and
- Access to required utilities (water, power, steam, etc.) during any removal effort.

1.2 REGULATORY BACKGROUND

The FMC Plant Operable Unit (OU) is a part of the larger Eastern Michaud Flats (EMF) Superfund Site, and is located in southeastern Idaho, approximately 2.5 miles northwest of Pocatello, Idaho. The EMF Site was listed on the National Priorities List (NPL) on August 30, 1990. The EMF Site includes two adjacent production facilities, a former FMC Corporation elemental phosphorus processing plant that ceased operation in 2001 and a phosphate fertilizer processing facility operated by the J.R. Simplot Company. The EMF Site encompasses both the FMC and Simplot plants and surrounding areas affected by releases from these facilities. FMC, Simplot and EPA entered into a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Administrative Order on Consent (AOC) in May 1991 under which the companies agreed to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the site. During the RI/FS the site was divided into three "Subareas:" 1) the FMC Subarea, consisting of the FMC Plant Site (where elemental phosphorus production took place) and other FMC-owned properties at the site; 2) the Simplot Subarea, consisting of the Simplot plant and other Simplot-owned properties at the site; and 3) the Off-Plant Subarea, consisting of the remainder of the site. EPA changed these designations to the FMC Plant OU, the Simplot Plant OU, and the

Off-Plant OU after its June 1998 *Record of Decision for the EMF Site* (*1998 ROD*, EPA, 1998).

FMC ceased production of elemental phosphorus from phosphate ore at its Pocatello facility in December 2001. This led EPA and FMC to enter into an AOC in October 2003 for a Supplemental Remedial Investigation and Feasibility Study (SRI/SFS AOC) at the FMC Plant OU. This was driven primarily by EPA's finding that additional investigations and evaluations were needed at the plant areas that had been actively operated at the time of the RI/FS but where operations had terminated with the plant shutdown. The Supplemental Remedial Investigation (SRI) was performed during two periods, June through December 2007, and October through December of 2008. It should be noted that the SRI did not include an intrusive field investigation concerning the buried railcars. All information in this paper is based upon historical documents and knowledge of the FMC phosphorus manufacturing operations at the FMC Plant Site.

1.3 FMC SITE DESCRIPTION AND OPERATIONAL HISTORY

1.3.1 FMC Site Description

The FMC Plant Site is located approximately 2.5 miles northwest of Pocatello, Idaho, and 1 mile southwest of the Portneuf River, a tributary of the Snake River. The FMC Plant Site is south of Highway 30, covers approximately 1,150 acres, and historically contained all of the process operations used for the production of elemental phosphorus. The Plant Site adjoins the western boundary of the Simplot Don Plant. There are an additional 212 acres owned by FMC located north of Highway 30 (excluding the 9-acre Tesco property) that are also part of the FMC OU, but which have not been identified as areas with P4 contamination. The FMC Plant OU is on privately-owned fee land, most of which is located within the exterior boundaries of the Fort Hall Indian Reservation.

A more detailed description of the site's physical characteristics can be found in Section 2.0 of the *SRI Report*. Additional detailed information on the geology and hydrogeology of the EMF Site study area and the FMC Plant OU is presented in Sections 3.1 and 3.3, respectively, of the *EMF RI Report* (BEI, 1996), as well as Section 2.0 of the *Groundwater Current Conditions Report for the FMC Plant Operable Unit* (MWH, 2008a).

1.3.2 Historic FMC Plant Process Description

The FMC Plant Site produced elemental phosphorus (P4) from phosphate-bearing shale ore mined regionally. Ore was shipped to FMC via the Union Pacific Railroad during the summer months and stockpiled. The ore was crushed, screened, and formed into briquettes prior to heat treatment (known as calcining). The calcining process involved heating the ore briquettes to a sintering temperature of approximately 1,200°F to form nodules. Carbon monoxide (CO), a by-product of the phosphorus furnace reaction, was used as fuel to fire the calciners. The nodules were blended with coke and quartzite

(known as silica) to make the phosphorus furnace feed. This mix of nodules, coke and silica was fed into four electric arc furnaces.

The furnace reaction primarily yielded gaseous P4, CO gas, slag, and ferrophos. Slag and ferrophos were "tapped" out of the bottom of the furnace through tapping holes in a molten state. Once cooled, the ferrophos was stockpiled and sold intermittently for metal recovery. For most of the life of the plant, slag was allowed to cool and harden, then was loaded into haul trucks and either hauled to the slag pile or to Bannock Paving, also located on site. Bannock Paving (BAPCO) crushed and sized the slag, which was sold primarily for use in road construction. The slag that was placed on the slag pile remains to this day. At full capacity, the process would generate approximately 1.7 million tons per year of slag. Approximately half of the slag was sold to BAPCO until the early 1990s when FMC discontinued sale of slag to BAPCO. The remaining slag was stockpiled on the slag pile and/or used on site for fill/roads. It is estimated that the slag pile currently contains over 14 million cubic yards of slag.

The P4 product was removed as a gas, along with CO gas, from the furnaces using vacuum pumps. This gas stream first passed through a pair of electrostatic precipitators, then through a water condenser that cooled the gas stream to below the P4 boiling point, thus condensing the P4 to a liquid. The liquid P4 collected in a sump in the furnace building floor. The liquid P4 was subsequently pumped to the phos dock where it was loaded into railcars for shipment. P4 will burn upon contact with air. Therefore, to prevent oxidation, the condensed phosphorus product was kept covered with water from the time it was produced through loading for transit off-site. To minimize shipping weight, water on top of the P4 in the railcar was pumped off prior to shipping and nitrogen gas was injected, again to keep air from contacting the P4 during transit.

1.3.3 Description of P4 Sludge Generation and Management

P4 was typically very pure, white phosphorus. However, due to a number of process variables, ore, silica and/or coke dust, along with other condensables would pass through the electrostatic precipitator in trace amounts and end up with the liquid P4 product. These insolubles would rise to the top of the liquid P4 as it was stored in a liquid state and eventually concentrate to form what was referred to as P4 sludge. The sludge typically ranged from 75 to 95% P4. The P4 sludge was much more viscous and would not easily pump from the sumps and tanks. Therefore, over time P4 sludge would build up within the storage vessels and railcars.

Given the high percentage of P4, every effort was made to remove and recover P4 sludge from sumps, tanks, and railcars. A process was installed at the phos dock to process the sludge through hydroclones and a centrifuge, which to a large degree separated the P4 from the insolubles. The insolubles along with some P4 were then pumped from the phos dock to the phossy water ponds where it would settle and accumulate. The processed, recovered P4, known as centrifuge product, was still not pure enough to ship as product. The centrifuge product was therefore pumped at a very low rate into the furnaces where it would be re-distilled into saleable P4.

SECTION 2.0 DESCRIPTION OF THE BURIED RAILCARS

2.1 RAILCAR BURIAL

After several shipments of P4, most returning railcars accumulated enough P4 sludge to warrant railcar cleaning. This was a difficult, hazardous task during which sludge inside the railcar was removed using a combination of pumping, steam cleaning and scraping/shoveling, often requiring employees to enter the railcar to manually clean the inside walls of the railcar. Railcar cleaning was performed at the phos dock where platforms for entry, hot water, steam, nitrogen, and extensive safety systems were readily available. The P4-rich sludge would then be processed through the centrifuge at the phos dock as described above, and the railcar would be placed back into service.

During transit, the railcars would cool and the P4 would solidify. Steam was used at the recipient plant to melt the P4 to a liquid state and then pump out liquid P4. Typically, railcars were outfitted with external steam jackets which allowed heating of the railcar and for cleaning of the railcar internals as described above. According to a July 1, 1981 internal FMC memo (see Attachment 1) written by the phos area supervisor, 30 used railcars were purchased to store sludge over a three-year period, 1962 through 1964. That action implied that the plant was experiencing very high P4 sludge production during that period. With the addition of the centrifuge process at the phos dock and lower sludge production rates, sludge generated from the end of 1964 onward was reprocessed through the furnaces.

These railcars were equipped with internal steam coils which prevented cleaning of the railcars at the phos dock using normal car cleaning procedures. The 1981 memo states,

> "*….the internal coils had to be cut out since they were approximately 8 inches off the bottom and prevented cleaning. Several near-miss accidents occurred as result of P4 entering leaking coils and burning or cutting causing extreme pressure plus spraying P4. Cleaned cars were scrapped or sold intact.*
>
> *Because of safety, approximately 21 railcars were removed from their trucks and hauled to the south end of the slag pile and buried with clay and covered with slag. This was done in the late fall of 1964."*

The 1981 memo indicates that all 30 railcars were first emptied of P4 sludge and processed at the phos dock through the centrifuge. This was completed by the end of 1964. Nine railcars were successfully cleaned and scrapped, and 21 were buried without being cleaned. Although it is impossible to know for sure, plant experience indicates that about 10 to 25% of the total sludge capacity would have remained in the 21 railcars at the time of burial. Figure 2.1 shows the railcars as placed south of the slag pile in 1964. Note that soil has been cleared under the burial site. It is presumed that this soil was used to cover the railcars with "clay" as described in the 1981 memo. The photo also confirms

that the railcars were placed at or below the original grade, and thus would be at the bottom of the current slag pile.

2.2 UNKNOWNS CONCERNING THE BURIED RAILCARS

The depth and location of the railcars within the slag pile can be estimated to within a few feet, based upon the original vs. current surface elevations and historical aerial photographs. However, there are several unknowns concerning the buried railcars that significantly hinder potential remedial actions. These unknowns are discussed in the following subsections.

2.2.1 Condition of the Railcars

The physical condition of the railcars is unknown. Their condition is important in determining whether or not the railcars could be handled whole once excavated. If the railcars have deteriorated through corrosion, any attempt at removing the entire railcar in one piece is likely to result in exposure of the P4 sludge to air and a P4 fire. It is presumed that the railcars were in good physical working condition at the time of the burial in 1964. However, the level of deterioration due to corrosion is unknown.

Based upon experience with mild steel underground piping at the plant site, the soil conditions do not result in significant corrosion on the outside of the piping. However, corrosion from the inside of mild steel equipment in phossy water service was observed due to oxidizing P4 which creates phosphoric acid. The phosphoric acid could cause significant corrosion from the inside, weakening the railcar. This could make exhuming the railcars in one piece impracticable. As discussed in the next subsection, the amount of phosphoric acid formed within the railcars, and therefore, the amount of internal corrosion since burial, is impossible to estimate. The worst case, i.e., that the railcars are greatly weakened by corrosion, would have to be assumed in evaluating the “excavate and treat” alternative. The remedial action evaluation thus must address potential methods for decontaminating and dismantling the railcars in place.

2.2.2 Contents of the Railcars

As described in Section 1.0, it is expected that the railcars contain about 10 to 25% of their total capacity as P4 sludge. However, it is not known if the railcars were filled with water or nitrogen prior to transportation to the slag pile area for burial. Nitrogen would have been a logical choice, given that it was present at the phos dock and used in railcar shipments. However, water may have also been used. The use of water would increase the likelihood that phosphoric acid would be formed, resulting in an increased rate of internal corrosion. The presence of water would also increase the amount of material to manage once the railcars were exhumed under an “excavate and treat” alternative. The worst case, i.e., that the railcars are filled with water, would have to be assumed in evaluating the “excavate and treat” alternative.

2.2.3 Whether the Railcars Have Already Leaked

The P4 sludge in the railcars would have been, and has remained, at subsurface soil temperatures since burial. These temperatures are below the melting point of P4. If P4 has leaked into soils at ambient temperatures, it would be assumed to have migrated no more than a foot from the point of the release and may have oxidized. However, upon removal of the railcar, any P4 that has accumulated in the soil outside the tank that has not oxidized would catch fire and burn. P4 can burn during most ambient conditions, including cold winter weather. The worst case, i.e., that the railcars have leaked and P4 is present in the soils near them, would have to be assumed in evaluating the "excavate and treat" alternative.

2.2.4 Remedial Action Site Worker

Site worker safety is one of the most difficult elements to resolve with respect to "active" ex-situ or in-situ handling and treatment of P4-contaminated soils. Exposure to P4 (solid, liquid, and vapor phases) and P4 reaction products (P_2O_5, other phosphorus oxides, phosphine, and phosphoric acid) present immediate physical hazards to site workers. These have been identified in the site-specific risk assessments performed by EPA (RI Report, 1996) and FMC (SRI Report, MWH, 2008) and by numerous medical, research, and environmental agencies including the Center for Disease Control and Prevention (CDC), the USEPA Integrated Risk Information System (IRIS), and the Cold Regions Research Engineering Laboratory (CRREL). These risks have been well documented by FMC and others that manufacture or formerly manufactured P4 in a commercial/ industrial setting, including Stauffer (Rhodia, 2007), Monsanto, and Albright and Wilson.

P4 is relatively safe when maintained under water and using well-engineered process equipment, experienced operators, and established procedures. However, P4 in the railcars and surrounding soils would present significant risks to remediation workers, especially given that the workers would be isolated within a large excavation with limited access/egress. The operations and maintenance personnel necessary for railcar excavation, removal and treatment would potentially be exposed to a wide range of health and safety risks due to the nature and extent of P4 that would have to be assumed in such an operation. The largely uncontrolled conditions during excavation could expose workers to fire, dermal, and respiratory hazards. Because of this concern, it is expected that the removal operations within the excavation would be limited to dismantling the railcars into manageable pieces. These pieces, stored under water, would then be transported out of the excavation site to be decontaminated in a separate structure located on site. This decon structure would be equipped with the necessary hot water, steam, nitrogen, safety systems and containment systems.

In most circumstances, it is expected that the excavation/dismantling and decontamination of the railcars would have to be managed in enclosed structures that would be vented to an air pollution control device to prevent releases to the ambient air. Workers within such structures would be required to wear Level A PPE, although significantly modified (if practicable) to protect them from P4 thermal exposure since

most Level A protective suits do not protect against P4 burns. P4-protective suits worn at most P4 manufacturing plants are constructed with an aluminum coating, designed to be immediately shed in the event of P4 exposure. This approach would not be consistent with PPE decontamination procedures typically applied within remediation exclusion zones or contamination reduction zones. Well-designed processes, highly-trained site workers, and a comprehensive Environmental, Health, and Safety Management System (including extensive health, safety and environmental procedures) would be critical, but might not be sufficient to ensure adequate protection of site workers. Cost considerations also would be significant, requiring quantification of the capital and O&M costs associated with providing adequate site systems if indeed such systems could be designed and reliably implemented. As such, adequate site worker health and safety remains an unknown.

2.2.5 Public Health and Safety

During operation of the FMC plant, public health and exposure often were controlled by the same measures that FMC put into place to keep plant workers safe. Typical engineering controls, such as fencing, prevented public access to hazardous areas throughout the site. Air monitoring and scrubbers were installed to meet Clean Air Act requirements to control phosphorus-related and other air emissions from the plant site. During any remedial action that involved the handling of P4-contaminated soils, engineering controls also would be in place to protect site workers. However, unlike controlled manufacturing processes, the excavation, removal, and decontamination of P4 sludge in (and potentially around) the buried railcars could cause uncontrolled releases, especially to the air, due to the widely varying site conditions and difficulty in designing appropriate engineering controls. Some of these difficulties are discussed in other reports (Rhodia, 2007). Short-term public exposures to airborne contaminants including P_2O_5, phosphine gas, and phosphoric acid also might occur, due to the many unforeseen circumstances that could arise. Therefore, the excavation, removal and treatment of the railcars may require an enclosure to contain potential air emissions, which would then be vented to large scrubbers or other air pollution control devices. As such, adequate protection of public health and safety remains an unknown.

2.2.6 Environmental Impacts

Environmental concerns related to the handling of P4-contaminated equipment and soils as would likely be encountered during railcar excavation, removal, and treatment include potential impacts to air and water/groundwater. The above discussion identifies possible worker risks from direct exposure to pure P4, phosphorus gases and contaminated process water, and risks to the public from air emissions and impacted groundwater. The following discussion addresses the release mechanisms potentially triggered by active or intrusive remediation of P4-containing railcars and soils.

Air Impacts: Intrusive remediation into P4-impacted soils or equipment, such as the buried railcars, could result in fire and P4 combustion products being released to the atmosphere. Their concentrations would depend in large part on the amount of P4

encountered during railcar excavation and the effectiveness of the engineering controls at the excavation, storage and treatment areas. If the gases were treated with activated carbon or dry filter systems, solid wastes would be generated. If these gases were to be captured and treated by a scrubber, the scrubber water would need to be treated in a waste water treatment (WWT) process. The WWT process typically would consist of neutralization (because of phosphoric acid capture by the scrubber), clarification, and sand filtration. Solids are removed by that process and consolidated by a filter press, then transported and disposed in a landfill depending on analytical testing. The water would be discharged for reuse in scrubber operations, directly discharged to the groundwater or surface water, or sent to a publicly-owned treatment works (POTW) for later discharge to surface water.

Water/Groundwater: Water would be necessary during most steps of a railcar excavation, removal and treatment process to prevent P4 exposure to oxygen in the air and resulting combustion. During railcar excavation and dismantling, water would likely be added to the excavation site as necessary to prevent/extinguish P4 fires. Water also would be necessary during the cleaning process in which P4 would be separated from the railcar structures.

Although water addition to simply "wet" the soil/slag in the excavation area (e.g., for dust control) would not be expected to represent a significant risk for mobilization of constituents to groundwater, the potentially significant water addition necessary to prevent or extinguish P4 combustion within the excavation/removal area could represent a risk for mobilization of constituents of concern (COCs) and impact to groundwater.

SECTION 3.0 PROCESS OPTIONS CONSIDERED

The following subsections provide a brief description of the different remediation process options considered and screened for the railcars at RU 19c.

3.1 CAP IN PLACE

This process option involves establishing the final grade of the surface of the slag pile and placement of a cap over the slag piles as well as the railcars. This process option has been retained.

3.2 INJECTION OF WET CONCRETE INTO THE RAILCARS AND LEAVE IN PLACE

This process option involves drilling down through the slag to each of the 21 railcars and injecting wet concrete into the railcar to stabilize and solidify the contents in place. The railcars would be left in place and capped.

The process option was rejected for the following reasons:

- While the location and depth of the railcars can be determined to within a few feet, it is unlikely that a drilling rig could accurately drill through 80 to 120 feet of slag and hit the top of each of the 21 railcars to allow for injection of the wet concrete. Due to the depth of burial of the railcars and the nature of slag placed in the pile (i.e., heterogeneous particle size distribution, slag 'monoliths' up to 20-feet in dimension and relatively high metals and radionuclide concentrations/activities in slag), remote sensing technologies such as ground penetrating radar, electromagnetic and/or density surveys would not be effective to refine the location and condition of each of the buried railcars.

- The expected reaction between the caustic concrete mix and the P4 inside the railcars would likely create a significant, uncontrollable reaction, including P4 or phosphine combustion and release of gases. This option would be expected to result in a scenario similar to what happened at the Tarpon Springs, Florida site where in-situ stabilization was attempted.

- If the railcars are filled with water, this could create or exacerbate leakage from the railcars to the surrounding soil.

- Without adequate mixing within the railcar, much of the P4 would likely remain un-reacted and therefore unstabilized although the contents would be encapsulated within the cured cement.

3.3 INJECTION OF WET CONCRETE AROUND THE RAILCARS AND LEAVE IN PLACE

This process option involves drilling down through the slag alongside each of the 21 railcars and injecting wet concrete around the railcar to encapsulate the contents in place. The railcars would be left in place and capped.

The process option was rejected for the following reasons:

- While the location and depth of the railcars can be determined to within a few feet, it is unlikely that a drilling rig could accurately drill through 80 to 120 feet of slag to accurately inject concrete around all 21 railcars to fully encapsulate the railcars. This would be especially difficult given the railcars were reportedly covered with soil. Due to the depth of burial of the railcars and the nature of slag placed in the pile (i.e., heterogeneous particle size distribution, slag 'monoliths' up to 20-feet in dimension and relatively high metals and radionuclide concentrations/activities in slag), remote sensing technologies such as ground penetrating radar, electromagnetic and/or density surveys would not be effective to refine the location and condition of each of the buried railcars.

- The expected reaction between the caustic concrete mix and any P4 that has leaked from the railcars would likely create a significant, uncontrollable reaction, including P4 or phosphine combustion and release of gases. This option would be expected to result in a scenario similar to what happened at the Tarpon Springs, Florida site where in-situ stabilization was attempted.

- Without adequate mixing in the soils around the railcars, likely much of the P4 would remain un-reacted and therefore unstabilized.

3.4 EXCAVATION, REMOVAL, AND TREATMENT OF THE P4 IN THE RAILCARS

This option involves excavation of the slag and soil over the railcars to expose them. The railcars would then be removed, either whole or by dissection, and cleaned. The P4 sludge would be containerized and treated off-site by incineration. This process option would include the following steps:

1. Excavation of slag down to the railcars. The railcars currently are buried beneath 80 feet (toward the western edge of the railcars) to 120 feet (toward the eastern edge of the railcars) of slag. Assuming that a 3:1 slope would be required for the excavation to safely allow equipment and personnel into the excavation working area, approximately 300,000 yd^3 of slag would have to be removed and stockpiled. Once the removal and treatment of the railcars was complete, the slag would likely have to be placed back into the excavation to allow for the appropriate final grading of the slag pile prior to capping.

2. Removal of soil covering railcars. As the railcars are reportedly covered with soil, the soil would have to be carefully removed from around all the railcars to

provide access. If the railcars have leaked, this soil could contain P4 and the P4-contaminated soil would have to be excavated and containerized.

3. Enclosure of the railcars. To prevent releases of P4 oxidation products, it is expected that the railcars would have to be enclosed in a structure to contain emissions. The structure would have to be equipped with a scrubber to capture and control those emissions. Therefore, a significant temporary electrical power source would be required within the excavation area. Water for firefighting would also have to be provided in that area.

4. Removal and containerizing water in railcars. Because it must be assumed that the railcars are filled with water, a pumping system would be required to remove and containerize that water. The water, approximately 15,000 gallons per railcar and 315,000 gallons total, would have to be temporarily stored, characterized, and potentially packaged in 55-gallon containers and shipped offsite for incineration (approximately 6,000 drums).

5. Dismantling the railcars into manageable pieces. Uncertainty regarding the extent of corrosion or other deterioration of the railcars requires an assumption that the railcars could not be removed in one piece. Thus each railcar would have to be cut up into pieces small enough to be placed in a drop bin filled with water. Although P4-contaminated equipment sometimes was cut up for decontamination within the decon building during plant operations, it is uncertain how this would be done on the scale of a railcar.

6. Decontamination of the railcar pieces. As discussed in Section 2.2.4, it is expected that decontamination of the dismantled railcar pieces would not be performed in the slag pit excavation, but in a separate decon structure. The drop bin containing the cut-up railcar pieces would need to be hauled out of the excavation to the decontamination "building." This building would have to be equipped with air pollution controls, a package boiler to generate steam (either electric or natural gas), water, electrical power, natural gas or propane heaters, a phossy water containment and treatment system to collect the removed P4 sludge, and safety systems typical of a P4 handling operation.

   The railcar pieces would be removed from the drop bin within the enclosure, steam cleaned, mechanically scrapped, and then heated to ensure all P4 was oxidized. The removed P4 would then be containerized and shipped off-site for incineration. Some of the railcar components, such as steam coils, would likely have to be cut up and placed into drums for shipment as the coils could not be effectively cleaned. While it is difficult to estimate the number of drums of P4 that would be shipped offsite for incineration, a conservative (low) estimate of 1,000 tons of P4 and P4-contaminated scrap would result in over 5,000 drums of P4 waste being generated.

7. Wastewater treatment and waste management. In order to minimize the amount of material to be shipped off-site for incineration, a wastewater treatment system would be required to separate P4-containing materials from water used in the cleaning process. In addition, there would be air pollution control wastes containing phosphoric acid, potentially P4, and other COCs that would have to be appropriately stored, transported, and disposed.

Based upon the difficulty of this process, the uncertainties involved, the potential for worker and public health and safety impacts, and the potential for impacts to the environment (air emissions and threats to groundwater) this process option has been rejected.

3.5 RECOMMENDED PROCESS OPTION

Given the above analysis and considering effectiveness, implementability and cost, the cap-in-place process option is selected for the following reasons:

- Given the depth of the railcar burial in slag, the railroad cars do not pose a human health or ecological risk. A remedial action decision to cap the slag pile, augmented by institutional controls prohibiting intrusive activities in the area of the rail cars, would provide additional protection against potential human health or ecological risks.

- No EPA exposure scenario anticipates human exposures to COCs at depths of 80 feet, or more, below grade. The final grading plan for the slag pile should continue to maximize total depth of coverage.

- Capping is a proven, accepted technology as shown in Table 1-1 of *Identification and Evaluation of P4 Treatment Technologies – January 2009* (MWH, 2009), including burial and capping of de-railed phosphorus product cars in Fairfield, California.

- The railcars, even if they have or will leak in the future, do not pose a threat to groundwater as P4 does not migrate when at ambient or subsurface soil temperatures. As documented in the Current Conditions Report for the FMC Plant OU, the slag pile (RU 19) and buried railcars (RU 19c) are not identified as sources of elemental phosphorus or elevated total phosphorus / orthophosphate in groundwater downgradient from these RUs. A final remedy for the slag pile is expected to include a focused groundwater monitoring program for this unit, as well as for the nearby old plant solid waste landfill (RU 19b).

- A cap placed on the graded slag pile, along with appropriate institutional controls, will assure protection against any potential threat to groundwater.

100 0 100 Feet

N

Bechtel Environmental, Inc.
SAN FRANCISCO

FMC IDAHO LLC
POCATELLO, IDAHO

Blow-Up of Area with Sludge-Filled Railcars at South End of Slag Pile

Job Number	Drawing No.	Rev.
20906	FIGURE 2.1	

REFERENCES

Bechtel Environmental, Inc. (BEI), 1996. *Remedial Investigation for the Eastern Michaud Flats Site.* Bechtel Environmental, Inc. Draft issued September 1995 and revised August 1996.

MWH, 2008. Supplemental *Remedial Investigation Report for the FMC Plant Operable Unit.* June 2008.

MWH, 2008a. Groundwater *Current Conditions Report for the FMC Plant Operable Unit.* October 2008.

MWH, 2009. *Identification and Evaluation of P4 Treatment Technologies.* January 2009.

Rhodia (Franklin Engineering Group), 2007. *Clarifier Waste Treatability Study Phase 1 – Information Gathering.* October 2007.

United States Environmental Protection Agency, 1998. *Record of Decision. Declaration, Decision Summary, and Responsiveness Summary for Eastern Michaud Flats Superfund Site, Pocatello, Idaho.* US EPA, Region 10. June 1998.

ATTACHMENT 1

Gordon Scherbel Memorandum

Date: July 1, 1981

To: N. H. Sheffield

From: G. H. Scherbel

Subject: Sludge Tank Car Burial

During the years 1962, 1963 and 1964 a total of 30 railroad oil tank cars were purchased for sludge storage. Nearly all had been filled by early 1964. With the addition of the Centrifuge, S.D.U. and lower sludge production they had all been unloaded by November 1964.

Several of the tanks were cleaned by cutting large walk in openings in the ends. However, the internal coils had to be cut out since they were approximately 8" off the bottom and prevented cleaning. Several near miss accidents occurred as a result of P_4 entering leaking coils and burning on cutting causing extreme pressure plus spraying P_4. Cleaned cars were scrapped or sold to McCarty's intact.

Because of safety approximately 21 were removed from their trucks and hauled to the South end of the slag pile and buried with clay, then covered by slag. This was done in late Fall of 1964. The June 1965 aerial photograph in the Maintenance Shop lunch-room shows the partially buried cars and the location.

G. Scherbel

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FMC Corporation

Via Email & 1st class mail

May 5, 2009

Ms. Kira Lynch, MS ECL-113
US Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Re: Administrative Order on Consent for Supplemental Remedial Investigation/Feasibility Study for the FMC Plant Operable Unit (U.S. EPA Docket No. CERCLA 10-2004-0010)
SFS Interim Deliverables:
Updated SFS Soil Remedial Technology Screening Table
Preliminary Technical Memorandum and Tables – Soil Remedial Areas and Assembled Remedial Alternatives for Soils

Dear Ms. Lynch:

As stated in your September 30, 2008 letter providing comments on FMC's draft July 15, 2008 Supplemental Feasibility Study (SFS) work plan, EPA recommended "adding a Technology Screening Memo deliverable into the schedule prior to performing detailed analysis of alternatives for the SRI FS and finalizing the ARARs." Pursuant to that recommendation, FMC has been working with the agency to prepare and submit drafts of key elements of the SFS for review, discussion and agreement prior to incorporation of these key elements in the complete draft SFS report. Specifically, FMC submitted the draft soil and groundwater remedial technology screening tables and a *P4 Remedial Technology Screening Memorandum* on January 16, 2009. These draft documents were subsequently reviewed and discussed in a meeting with the US EPA, the Idaho DEQ and the Shoshone Bannock Tribes on February 25 and 26, 2009. As we agreed during that meeting, FMC incorporated the agencies comments and suggestions into the soil and P4 technology screening tables and, in conformance with your suggestions and guidance, has prepared a draft of assembled remedial alternatives for soils that applies a spectrum of the soil remedial technologies that we agreed „passed' the technology screening as summarized on the soil and P4 technology screening tables. As we also agreed in the February 25 and 26 meeting, these draft combined remedial alternatives for soils will be discussed in a meeting in Seattle May 20 and 21, 2009.

FMC

In preparation for the May 20 and 21, 2009 meeting, enclosed please find the following deliverables:

1) Updated technology screening table for soil (Table 6.1 - Soil Remediation Technology Screening Table);
2) A technical memorandum discussing the assembly of soil remedial alternatives (*SFS Interim Deliverable – Assembled Soil Alternatives for the FMC Plant Operable Unit*); and,
3) A draft initial screening table for assembled soil alternatives ("Assembled Soil Remediation Alternatives, Initial Screening, and Selection").

You will note that these deliverables do not include a discussion of FMC's northern properties because the final analytical data and risk assessment work is pending. Final fluoride data is expected later this month, and preliminary risk assessment work for available, validated analytical data will be presented at the meeting on May 20 and 21. A path forward for incorporation of the northern properties into these remedial alternatives tables will be discussed at that meeting.

Additionally, this letter serves to update the agency on the status of other associated work, specifically:

1. Groundwater technology screening table - The groundwater technology screening table (SFS Table 6-2, discussed during February 25 and 26, 2009 meeting) is still being updated. The agency requested additional consideration and evaluation of the potential applicabilty of in situ treatment technologies and while the additional evaluations are proceeding, they are not complete. FMC will update the agency on further consideration of in situ groundwater remedial technologies at the meeting on May 20 and 21, 2009.

2. Assembly of groundwater remedial alternatives – Preliminary conceptual approaches will be reviewed with the agency at the meeting on May 20 and 21, 2009. This level of review and discussion should be similar to that which we had on soil alternatives in February, when preliminary conceptual approaches were reviewed.

3. Rail car remediation evaluation memorandum – The agency requested that FMC consider and evaluate the potential removal and treatment of the rail cars buried in the slag pile. A thorough review and evaluation has been conducted, and is in the process of being documented. FMC did not wish to delay submittal of the draft assembled soil alternatives to await the Rail Car remediation evaluation memo, so that memo will be forwarded as soon as it is available, and in advance of the meeting on May 20 and 21, 2009 to allow for well considered discussion.

4. SFS Work Plan Comments – While the EPA has not formally responded in writing to FMC's November 14, 2008 response to EPA's comments on the SFS Work Plan, we have engaged in various discussions regarding those responses and submitted drafts of supplemental ARARs tables and discussed RAOs for P4 and surface water. FMC is compiling an addendum to its November 14, 2008 response to EPA comments reflecting these subsequent discussions for submittal later this month, and in advance of the May 20 and 21 meeting, should further discussion be required.

We will be forwarding a detailed draft agenda for the May 20 and 21 meeting under separate cover within a few days.

Please call me with any questions, or to discuss further.

Sincerely,

Barbara E. Ritchie
Associate Director, Environment
FMC Corporation

Enclosure (4 copies)

Cc: Doug Tanner (2 copies)
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FMC Idaho LLC, Pocatello, Idaho

Interim Deliverable

Assembled Soil Alternatives for the FMC Plant Operable Unit

May 2009

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ACRONYMS/ABBREVIATIONS

AFC	alternative final cover
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDC	Center for Disease Control and Prevention
CO	carbon monoxide
COC	contaminant of concern
CRREL	Cold Regions Research Engineering Laboratory
EPA	Environmental Protection Agency
ET	evapotranspiration
FeP	ferrophos
FMC	FMC Corporation
FS	feasibility study
IDEQ	Idaho Department of Environmental Quality
IRIS	Integrated Risk Information System
OU	operable unit
P4	elemental phosphorus
PH_3	phosphine
P_20_5	phosphorous pentoxide
PPE	personal protective equipment
POTW	publicly-owned treatment works
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RU	remediation unit
SFS	Supplemental Feasibility Study
SRI	Supplemental Remedial Investigation
SWMU	solid waste management unit
USEPA	United States Environmental Protection Agency
WWT	wastewater treatment

Section 1.0 Introduction

1.1 BACKGROUND

As part of the supplemental feasibility study (SFS) for the FMC Plant OU, soil technologies were evaluated for remediation of site contaminants of concern (COCs) that were identified through several phases of remedial investigation (RI), including the recently completed supplemental RI (SRI). During a meeting with EPA, IDEQ, and the Shoshone Bannock Tribes on February 23-24, 2009 in Salt Lake City, soil technologies and process options for soil remediation were evaluated and either accepted and rejected based on their effectiveness, implementability, and cost according to procedures outlined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (*EPA RI/FS Guidance*; EPA, 1988). Technologies and individual process options that passed this screening have been assembled in this document to create five alternatives for soil remediation of the FMC Plant OU. These assembled alternatives have been developed to meet the remedial action objectives (RAOs) for the FMC Plant OU.

In this document, only soil alternatives are presented, however, at a later date groundwater alternatives will also be submitted for review. Alternatives from each media that are recommended based on the initial screening for effectiveness, implementability and cost will be combined and then undergo the 9-step detailed analysis in the last step of the FS process as recommended in the *EPA RI/FS Guidance.*

1.2 OBJECTIVE AND SCOPE OF THIS PAPER

The objective of this memorandum is to provide the technologies, processes, and procedures that will be integral pieces of each of the assembled alternatives for the FMC Plant OU. Below the information contained in each of the remaining sections is summarized.

Section 2 – Common Elements of the Assembled Alternatives. This section provides details regarding remedial actions that are common to all alternatives. For example, cap grading, integration, and related stormwater management will be necessary depending on the extent of capping under each of the alternatives and is discussed in this section. Also discussed are necessary institutional controls, soil management plans, and fugitive dust controls plans. In addition, groundwater monitoring will be summarized as will initial monitoring for gases either around the perimeter or on the cap surface depending on the construction of the cap (i.e., multi-layered and/or evapotranspiration [ET] caps).

Section 3 – Cap Descriptions. In this section, the three proposed cap designs are discussed. The anticipated cap designs for Gamma radiation (the Gamma Cap), ET caps, and multi-layered caps are presented as are the some of the construction specifications.

Section 4 – Description of the Remediation Areas. To facilitate the evaluation of the alternatives in the FS process, the FMC Plant OU was divided into remedial areas (RAs) as indicated in the figures associated with each alternative. In general, the RAs are defined based on physical

location and similarity of contaminants of concern (COCs) and the remedial approach. The RUs contained within each remedial area and the grouping rationale is summarized in this section.

Section 5 - Detailed Descriptions of each Alternative. In this section, remedial actions to be conducted in each of the RAs discussed in Section 4 are detailed. In addition, remedial activities unique to each alternative are discussed.

1.3 Historic FMC Plant Process Description

The FMC Plant Site produced elemental phosphorus (P4) from phosphate-bearing shale ore mined regionally. Figure 1-2 shows the location of process areas of the site and the remediation units (RUs) identified for performing the SRI. Ore was shipped to FMC via the Union Pacific Railroad during the summer months and stockpiled (in RU 7). The ore was crushed, screened, and formed into briquettes prior to heat treatment (known as calcining). The calcining process (located within RU 8) involved heating the ore briquettes to a sintering temperature of approximately 1,200°F to form nodules. Carbon monoxide (CO), a by-product of the phosphorus furnace reaction, was used as fuel to fire the calciners. The nodules were blended with coke and quartzite (known as silica) to make the phosphorus furnace feed. This mix of nodules, coke and silica was fed into four electric arc furnaces (located within RU 1). The furnace reaction primarily yielded gaseous P4, CO gas, slag, and ferrophos (FeP). The P4 gas was subsequently condensed to a liquid state and stored in sumps and tanks in the furnace building and phos dock prior to shipment off-site as product.

P4 will burn upon contact with air. Therefore, to prevent oxidation, the condensed phosphorus product was kept covered with water from the time it was produced through loading and transport off-site. All of the elemental phosphorus product manufacturing and handling processes were located within RU 1, with the exception of long-term phosphorus storage tanks located in RU 6.

Process water (known as phossy water) was used to isolate elemental phosphorus from contact with air and to slurry precipitator dust (a furnace by-product). Phossy water and precipitator slurry were typically managed separately in a series of surface impoundments located to the west of the elemental phosphorus furnaces. A number of these surface impoundments (Ponds 8S, 11S, 12S, 13S, 14S, 15S, 16S, 17S, 18A, 8E, and 9E) were closed and capped under EPA-approved RCRA closure plans and are not subject to the SRI/SFS (designated as RU 22a). Numerous other surface impoundments were historically dewatered and/or covered. These ponds, which had ceased receiving wastes prior to termination of their Bevill exemption and thus were not subject to RCRA, are located within RU 22b. The railroad swale (designated as RU 22c) was designed as a stormwater retention area but also received phossy water (and therefore P4) from process spills in the furnace building and phos loading dock.

More detailed information regarding the ore processing, by-product handling, and waste management operations at the FMC Plant Site is provided in Sections 1.1.2 through 1.1.3 of the *EMF RI Report* and Section 1.3 of the *SRI Report for the FMC Plant Operable Unit.*

Section 2.0 COMMON ELEMENTS OF THE ASSEMBLED ALTERNATIVES

For all of the assembled alternatives, there are common elements which will be incorporated into the remedial design and will be integral parts of any selected alternative. While these common elements may vary somewhat from one assembled alternative to another and likely will not be concisely defined until the Remedial Design, a general discussion of each is provided below. Sections 2.1 through 2.7 would be components of all alternatives; Section 2.8 describes elements which would need more consideration in alternatives including more active treatment of elemental phosphorus (P4).

2.1 INSTITUTIONAL CONTROLS

Institutional controls will be a significant component of any selected alternative. Institutional controls may apply to all or part of the site and may include any or all of the following, in addition to those institutional controls already in place:

- Access controls consisting of fencing, entrance gate controls, site entrance logs, warning signs, and/or required training.
- Land Use Covenants, such as deed restrictions, establishing controls on one or more of the following:
    - Restrictions on the types of activities and/or development (e.g., limited to commercial or industrial);
    - Prohibition of intrusive activities, construction and/or excavation on ET or multi-layer caps and compliance with soil/fill management plan on gamma caps;
    - Requirements for soil/fill management (see discussion below),
    - Restrictions on the use of shallow/impacted groundwater, and/or
    - Notices such as already in place for the closed RCRA Ponds

2.2 SOIL/FILL MANAGEMENT

A soil/fill management plan would be incorporated into deed restrictions to ensure that disturbance, management, and/or disposition of site impacted soil/fill is controlled. The soil/fill management would be designed to control redistribution of impacted soil/fill. Soil management would likely include prohibition of excavation in areas containing ET or multi-layer caps as well as strict management of excavated soil/fill in areas where excavation may be allowed (e.g., utility trenching on a gamma cap).

2.3 CAP INTEGRATION, MONITORING AND MAINTENANCE

2.3.1 Cap Integration with Existing Site Features

The site currently has eleven (11) ponds which were capped and closed pursuant a RCRA Consent Decree and the applicable RCRA regulations. These ponds (known as the RCRA Ponds) are currently being managed under RCRA post-closure plans. There are also five (5) ponds (known as the Calciner Ponds) that were capped and are currently being managed under a Voluntary Consent Order with the State of Idaho. Each of the assembled alternatives would require construction of one or more caps that would abut to and/or intersect with one or more of the caps that are already in place. In addition, there will likely be several instances where caps that are constructed as part of the CERCLA Remedial Action will intersect. Therefore, careful consideration will be required during the Remedial Design to ensure that the:

- Intersection of caps will maintain the integrity and performance of both caps.
- Cap grading design will adequately control and provide management of stormwater runoff.
- Access roads (e.g., roads to RCRA ponds, power substations, etc.) are maintained and integrated into the cap design, as appropriate.
- Existing easements and infrastructure (e.g., active power lines, Don substation, etc.) are integrated into the cap design.
- Monitoring wells, pond leachate collection systems, and other monitoring and/or maintenance systems are integrated into the cap design and remain functional and accessible.

2.3.2 Cap Monitoring

As is required and performed on existing site caps, any new caps installed as part of the selected remedy, would require long-term monitoring. The conceptual strategy for the cap monitoring would be initially developed in the SFS detailed analysis and then finalized and documented in the Remedial Design. This cap monitoring would likely include:

- Groundwater monitoring down gradient of certain capped areas (e.g., capped landfills, capped former pond areas, capped areas containing P4);
- Settlement monitoring;
- Erosion monitoring (periodic and after certain storm events);
- Vegetation monitoring on the surface of the capped areas;
- Security monitoring (fences, signage, etc.); and
- Stormwater/precipitation drainage system monitoring.

2.3.3 Phosphine (PH3) Monitoring

Elemental phosphorus is known or suspected to be present in subsurface soil/fill in the following areas:

- Furnace building, phos dock, and secondary condenser area (RU 1) including within the capillary fringe immediately down gradient of this area;
- Slag pit area (RU2);
- Pond 8S recovery process area (RU 13);
- Railcars buried within the slag pile (RU 19c);
- Former phossy ponds and precipitator slurry ponds (RU 22b);
- Railroad swale (RU 22c); and
- Areas with underground piping that conveyed CO gas (in RU 8), precipitator slurry/phossy water (in RUs 1, 2, 12, 13, and 22b), and some storm sewers (in RU 3).

Experience at Pond 16S (one of the capped RCRA ponds) has shown that PH3 can accumulate under synthetic cap layers (e.g., flexible membrane liners). The areas listed above would not be expected to generate or accumulate PH3 at levels found at Pond 16S as conditions within these areas are not similar to Pond 16S (i.e., there should be very little free water present, the pH is different, and similar co-mingled wastes are not present). However, PH3 generation may occur in those areas where P4 and water are present, although at expected rates much lower than at Pond 16S. Therefore, PH3 monitoring is warranted in these areas if P4 is capped in place to ensure that PH3 is not accumulating to levels that would threaten human health or the environment. This monitoring would be implemented for any type of cap placed over these areas and would contain the following elements:

- Monitoring the surface of the cap to identify PH3 releases to ambient air through the cap; and
- Monitoring the shallow subsurface around the cap to identify releases of PH3 from the perimeter of the cap.

This monitoring would continue on a periodic basis (e.g., semi-annually) until the first 5-year review at which time the need for further monitoring would be reviewed. The conceptual strategy for the PH3 monitoring would be initially developed in the SFS detailed analysis and then finalized and documented in the Remedial Design.

2.4 STORMWATER MANAGEMENT

Site-wide stormwater runoff management will be critical to minimize cap erosion and ponding/infiltration at areas where leachable COCs remain in the soil/fill. Stormwater would be addressed by site-wide grade planning, integration into cap design, and collection of stormwater to minimize degradation of the caps and maintains a zero discharge of stormwater from the site to surface waters. One or more stormwater retention basins would likely be needed for stormwater management. The final grading and stormwater management design will be developed in the Remedial Design.

2.5 FUGITIVE DUST CONTROL

Fugitive dust generation on the site would need to be controlled during the construction phase and the implementation phase of the Remedial Action. Given the significant earthmoving

activities associated with any of the assembled alternatives (except "No Action"), fugitive dust control (including control of phosphorus pentoxide [P2O5] generated from potential P4 fires) during the construction phase will be a significant challenge. Fugitive dust mitigation during the construction phase would likely include:

- Maintaining existing site vegetation wherever possible (undisturbed areas);
- Application of water and dust control agents to active unpaved roadways;
- Use of existing paved roadways to the extent practicable; and
- Application of water, dust control agents and other best management practices in areas of active earthmoving (excavating and/or placement).

Fugitive dust mitigation during the Implementation phase would likely include:

- Establishing and maintaining vegetation on all cap surfaces;
- Application of water and dust control agents to unpaved active roadways;
- Use of paved roadways to the extent practicable.

In alternatives that include excavation in P4 areas, use of water in modified conventional excavation and in the handling/processing of P4 impacted soil/fill to minimize airborne releases is discussed further in Section 2.8.

2.6 GROUNDWATER MONITORING

Monitoring of site groundwater would be performed to evaluate the performance of the remedial actions and more fully discussed in the discussion of assembled remedial alternatives for groundwater to be submitted at a later date. The existing groundwater monitoring well network, including the designated RCRA and Calciner Pond groundwater monitoring well networks, on the FMC Plant OU will be the core of the Remedial Action groundwater monitoring network. In addition, while groundwater monitoring will similarly be a core component of all groundwater remedial alternatives developed, it is important to note that the capping alternatives for the site landfills (RU 17, 18, and 19b) will also incorporate the construction and installation of additional groundwater monitoring wells. The location of these wells will be determined through groundwater modeling and the development of the final site grading plan as part of the Remedial Design. In keeping with the "one clean-up initiative", groundwater monitoring as part of the Remedial Design will be integrated and coordinated with the RCRA and Calciner Pond groundwater monitoring program.

2.7 ANCILLARY P4 TREATMENT PROCESSES AND ISSUES

When addressing P4 impacted soils/fills in the assembled soil alternatives, it is important to recognize that any ex-situ P4 treatment technology will require several ancillary process steps in order to be implemented. These ancillary process steps are common to many of the treatment technologies. Ancillary process steps that would be integral to the treatment process must be considered when screening/evaluating potential technologies using the standard EPA decision criteria of implementability, effectiveness, and cost. Common ancillary P4 treatment processes for soils/fill materials include the following:

- Material/waste handling issues:
    - P4 excavation processes necessary to get P4-impacted materials to an ex-situ treatment process; and
    - P4-impacted material transportation to the ex-situ treatment process, and temporary storage of such material near the treatment process to provide surge capacity.
- Treatment process feedstock preparation:
    - Sizing, such as crushing and screening, of the material to provide a consistent feed particle size to the ex-situ treatment process; and
    - Blending with other extracted streams or inert materials of the feed to provide consistent P4 content to the ex-situ treatment process.
- Management of treatment residues:
    - Treatment of wastewater, further treatment and disposal of solid residues, and collection and treatment of process off-gases.

There are also several engineering and safety challenges, unique to P4 waste handling and treatment, that must be identified and addressed in the overall technology treatment evaluation using the fundamental decision criteria of implementability, effectiveness, and cost. These include the following:

- Site worker health and safety;
- Public health and safety; and
- Potential environmental impacts.

2.7.1 Site Worker Health and Safety

Site worker safety is one of the most difficult elements to resolve with respect to "active" ex-situ or in-situ handling and treatment of P4-contaminated soils. Exposure to P4 (solid, liquid, and vapor phases) and P4 reaction products (P_2O_5, other phosphorus oxides, phosphine, and phosphoric acid) present immediate physical hazards to site workers. These have been identified in the site-specific risk assessments performed by EPA (RI Report, 1996) and FMC (SRI Report, 2007) and by numerous medical, research, and environmental agencies including the Center for Disease Control and Prevention (CDC), the USEPA Integrated Risk Information System (IRIS), and the Cold Regions Research Engineering Laboratory (CRREL). These risks have been well documented by FMC and others that manufacture or formerly manufactured P4 in a commercial/industrial setting, including Stauffer (Rhodia), Monsanto, and Albright and Wilson.

P4 is relatively safe when maintained under water and using well-engineered process equipment, experienced operators, and established procedures. However, when not under a blanket of water or other inert material, the P4 operations and maintenance personnel necessary for the remediation activities would potentially be exposed to widely ranging physical risks due to the nature and extent of P4 in certain areas of the FMC Plant Site. The largely uncontrolled conditions during excavation could expose workers to fire, dermal, and respiratory hazards. In some instances, to control risk of airborne releases, excavation and/or processing would likely

occur in an enclosed structure, vented to an air pollution control device (as further discussed in 2.7.2). Workers within such enclosures would be required to wear Level A PPE, although significantly modified (if practical) to protect them from P4 thermal exposure (e.g., most Level A protective suits do not protect against P4 burns). P4 protective suits worn at most P4 manufacturing plants were constructed with an aluminum coating, designed to be immediately shed in the event of P4 exposure. This approach would not be consistent with most PPE decontamination procedures typically applied within remediation exclusion zones or contamination reduction zones. Well-designed processes, highly-trained site workers, and a comprehensive Environmental, Health, and Safety Management System (including extensive health, safety and environmental procedures) would be critical, but might not be sufficient to ensure adequate protection of site workers. Cost considerations also would be significant, requiring quantification of the capital and O&M costs associated with providing adequate site systems if indeed such systems could be designed and reliably implemented.

2.7.2 Public Health and Safety

During operation of the FMC plant, public health and exposure often were controlled by the same measures that FMC put into place to keep plant workers safe. Typical engineering controls prevented public access to hazardous areas throughout the site (e.g., fencing). Air monitoring and scrubbers were installed to meet Clean Air Act requirements to control phosphorus-related and other air emissions from the plant site. During any remedial action that involved the handling of P4-contaminated soils, engineering controls also would be in place to protect site workers. However, unlike the controlled manufacturing process, excavation and treatment of P4 wastes could cause uncontrolled releases, especially to the air, due to the widely varying site conditions and difficulty in designing appropriate engineering controls. The risk of uncontrolled air releases would increase with the quantity of P4-soils being remediated, as well as the degree of impact, e.g., active remediation of higher concentrations of P4 in impacted materials and greater quantities of impacted materials has greater risk than active remediation of lower concentrations and smaller quantities. Some of these difficulties are discussed above and in other reports (Rhodia, 2007). Short-term public exposures to airborne contaminants including P_2O_5, phosphine gas, and phosphoric acid also might occur, due to the many unforeseen circumstances that could arise. For alternatives that contemplate the excavation or processing of quantities of P4 which could result in a fire too large to be readily extinguished with conventional methods, an enclosure could be required to contain potential air emissions. The enclosure would then be vented to large scrubbers or other air pollution control devices.

2.7.3 Environmental Impacts

Environmental concerns related to the handling of P4-contaminated soils include potential impacts to air and water/groundwater. Possible worker risks from direct exposure to pure P4, phosphorus gases, and contaminated process water and risks to the public from air emissions and impacted groundwater are described above. The following discussion addresses the release mechanisms potentially triggered by active or intrusive remediation of P4-containing soils, which often also contain heavy metals and radionuclides, and the resulting potential on- and off-site impacts.

Air Impacts: Intrusive remediation into P4-impacted soils, including excavation, grinding, and/or sizing, could result in fire and P4 combustion products being released to the atmosphere. Their concentrations would depend in large part on the amount of P4 contamination, the quantity of P4-impacted soils being remediated, and the effectiveness of the engineering controls at the excavation, storage and processing areas. If the gases were treated with activated carbon or dry filter systems, solid wastes would be generated. If these gases were to be captured and treated by a scrubber, the scrubber water would need to be treated in a waste water treatment (WWT) process. The WWT process typically would consist of neutralization (because of phosphoric acid capture by the scrubber), clarification, and sand filtration. Solids are removed by that process and consolidated by a filter press, then transported and disposed in a landfill depending on analytical testing. This material could be high in heavy metals and/or radionuclides. The water would be discharged for reuse in scrubber operations, directly discharged to the groundwater or surface water, or sent to a publicly-owned treatment works (POTW) for later discharge to surface water.

Water/Groundwater: Water would be necessary during most steps of a P4 material handling process to prevent P4 exposure to air (oxygen) that would result in P4 combustion. During initial intrusive soil work, water would be added to the excavation as necessary to prevent/extinguish a fire. Water would also be necessary during many of the material handling processes, such as material sizing.

During modified conventional excavation, water would be added to the excavation to prevent/extinguish any P4 combustion. Water would also likely need to be added to each excavator bucket load for transfer to trucks and/or roll-off containers. Although water addition to simply "wet" the soil in the excavation (e.g., for dust control) would not be expected to represent a significant risk for mobilization of constituents to groundwater, the potentially significant water addition necessary to prevent or extinguish P4 combustion within the excavation area could represent a risk for mobilization of constituents of concern (COCs) and subsequent impact to groundwater.

Water would also be necessary in the tank or truck trailer to prevent P4 ignition while being transported from the excavation area to a material handling/processing area. In the material handling/processing area, water might be used in the sizing process or used to cover the P4-contaminated soil. Prior to a caustic hydrolysis treatment process, additional water would be added to prepare the 15% slurry feed. Water also would be used in the scrubbers that would be necessary to control emissions of P4-related gases at any locations in the handling process, such as the excavation and storage areas, where such emissions would occur.

In addition to using water to prevent/control fires during modified conventional excavation, process water might be lost to the environment during any phase of the excavation, transportation, storage, and/or treatment process. If released in significant volumes and in areas where soil/fill contains mobile COCs, water could provide sufficient hydraulic head to mobilize those COCs and create a source of impact to shallow groundwater.

Section 3.0 CAP DESCRIPTIONS

Each of the alternatives for remediation of the FMC Plant OU (except "No Action") has one or more cap types depending on the risk threats posed by various site COCs prior to capping. Threats in this case include risks to human health (i.e., ingestion, exposure, dermal absorption, exposure to fire, and inhalation) and/or the environment (i.e., migration to groundwater). Three cap types are described in the following subsections including gamma cap, evapo-transpirative (ET) cap, and multi-layer cap. These are organized from the most simplistic/least costly to the most complex/most costly to construct. Because of their design differences, these caps satisfy various site remedial action objectives (RAOs). Below the various cap designs and the RAOs that each design satisfies are discussed.

3.1 GAMMA CAP

Gamma caps involve placement of one foot of native soil (seeded to establish a vegetative cover) to eliminate gamma exposure. Test plots constructed at the FMC Plant OU as well as modeling (using MicroShield) have shown that less than one foot of native soil cover is sufficient to reduce exposure to gamma radiation to achieve the RAO for external exposure to radionuclides in soil. However, one foot of soil is generally required to provide adequate substraight for vegetation. Gamma caps also achieve the RAOs for incidential ingestion, dermal absorption, and inhalation, by providing sufficient barrier between impacted soils/fill and hypothetical future workers. Gamma caps, together with the other core, common remedial elements (e.g., effective sloping and stormwater controls) also reduce infiltration of precipitation but may not be sufficient to fully achieve the RAO of reducing the release and migration of COCs to groundwater in areas where COCs are most leachable. Specifically, a Gamma cap is not appropriate in areas of the Site that contain arsenic and P4 at levels that threaten groundwater.

3.2 ET CAP

The U.S. EPA's 2003 landfill guidance document entitled *Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Covers* states,

> "Modern engineered landfills are designed and constructed to minimize or eliminate the release of constituent into the environment (EPA, 2003). Solid (Subtitle D regulations) and hazardous waste (Subtitle C regulations) are required by federal, state, and/or local regulations to cover waste materials prior to or as part of final closure. These final covers are only one element of the landfill systems. Clearly the solid and hazardous waste regulations include language and provide mechanisms to support the permitting, design, construction, and maintenance of landfills with alternative covers. In fact, while the current federal regulations contain provisions for the construction of

> regulations-prescribed landfill cover, there are no specific provisions requiring the use of a "conventional" cover or disallowing the use of an alternative landfill cover."

As discussed above, the Subtitle C and D regulations allow oversight agencies the flexibility to approve alternative final cover (AFC), commonly referred to as an ET soil cover, if the alternative design includes an infiltration layer that "will result in an equivalent net reduction in infiltration as that provided by conventional covers". Most of the AFCs employ the principle of "water balance" to minimize percolation (Benson et al., 2001). This principle involves designing the AFC around a homogenous soil layer to store precipitation that is subsequently removed through ET. The thickness of the soil layer is chosen to allow for sufficient storage of all infiltration water during periods of low ET. The movement of water from the soil to the atmosphere is controlled by the amount of evaporation and transpiration by vegetation, which are greatest during the warm dry growing seasons. ET soil covers are highly implementable due to them being constructed of readily available native soil and vegetation.

ET soil covers have been used in arid and semi-arid regions of the western United States and have been effective at eliminating infiltration of precipitation and isolating waste. Because ET soil covers use native soil and vegetation, they are easier to implement than the multi-layered cap option. In addition, the performance of ET soil covers is comparible to multi-layered caps and when properly designed can provide the same level of protection for less cost.

The ET cap design, when combined with institutional controls that limit excavation through the cap, satisfies RAOs for preventing potential future receptor exposures posed by various site contaminants to: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to fire, and 5) inhalation of fugitive dust. In addition, an ET cap when properly designed is appropriate in certain areas of the Site so as to reduce the release and migration of COCs to groundwater.

3.3 MULTI-LAYER CAP

This cap involves the construction of a multi-layered cap with at least one hydraulic barrier layer consisting of either a compacted clay layer or geomembrane layer. In addition to the hydraulic barrier layer, the cap would incorporate a drainage layer and vegetation layer. Due to the semi-arid location of the facility, compacted clay layers may be subjected to desiccation and cracking due to shrinkage of the clay. In addition, there are no suitable sources of clay borrow sources identified nearby and therefore would require importing of large quantities of material for a compacted clay layer. An alternative to a compacted clay layer would involve using some type of geomembrane/geotextile layer to serve as the hydraulic barrier layer.

The multi-layered cap involves the construction of at least one hydraulic barrier layer consisting of compacted clay or geomembrane layer to eliminate future groundwater impacts by preventing infiltration of precipitation into underlying contaminated soils and

leaching of COCs into groundwater. Although multi-layered caps are implementable (provided that sufficient quantity of clay or geomembrane are available) and proven to be effective at reducing future groundwater impacts, ET caps can effectively be substituted because their performance is equivalent. Because of the complexity of the Muti-layered cap design, this cap has a higher construction cost than the other caps. In addition, the lack of nearby clay borrow sources and the difficulty in procuring and placing very large areas of geomembrane liner makes the multi-layered cap more difficult to implement than other caps identified.

The multi-layered cap design, when combined with institutional controls that limit excavation through the cap, satisfies RAOs for preventing potential future receptor exposures posed by various site contaminants to: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to fire, and 5) inhalation of fugitive dust. In addition, a multi-layered cap can be used to reduce the infiltration of precipitation and leaching of COCs to groundwater in certain areas of the Site. However, when compared to ET caps, the multi-layered cap is no more protective of groundwater, is complex to construct, and more costly. Depending on the quantity of geomembrane required, implementation may require more time, and certainly consumes more natural resources in its production.

Section 4.0 DESCRIPTION OF REMEDIATION AREAS

4.1 TRANSITION FROM REMEDIATION UNITS (RUs) TO REMEDIATION AREAS (RAs)

As part of the SRI/SFS scoping and planning activities, the impacted areas of the FMC Plant OU were divided up into 24 Remediation Units (RUs). An RU was intended to delineate one or more Solid Waste Management Units (SWMUs) with similar former processes or characteristics (including types of constituents of potential concern) and typically in the same geographical area of the FMC Plant OU. The *SRI Work Plan* was based upon investigation of these RUs.

Upon completion of the SRI, the contamination assessment of each RU has shown many of the RUs to have similar characteristics, warranting evaluation of similar remedial approaches. As the site moves into the SFS, combining (or in some cases dividing) RUs into new geographical areas will facilitate the SFS process and the RD/RA. These new areas are referred to as Remediation Areas (RAs). In general, the RAs are defined based on geographic proximity, similarity of contaminants of concern (COCs), and a consistent remedial approach. A description of each RA is presented in Table 4.1 which also includes:

- The RUs contained within the RA;
- The grouping rationale for each RA;
- A listing of RCRA SWMUs within each RA;
- The Exposure Scenarios of Concern associated with each RA (or subarea within an RA) prior to Remedial Action; and
- The RAO(s) that must be addressed for each RA with Remedial Action.

Section 5.0 DESCRIPTION OF ASSEMBLED SOIL ALTERNATIVES

In this section, five (5) assembled soil alternatives are discussed in detail. Note that many of the common elements described in Section 2 are integrated into these assembled alternatives and will only be discussed if unique.

5.1 "NO ACTION" ALTERNATIVE 1

"No Action" is a base case alternative and is required by NCP (EPA, 1988). For the FMC Plant OU, this alternative would represent the status quo. However, no long-term CERCLA groundwater monitoring (as is currently conducted voluntarily by FMC) would be performed. The institutional controls that are currently in place would remain in place.

5.2 ASSEMBLED SOIL ALTERNATIVE 2 (SEE FIGURE 1)

5.2.1 Use of ET Caps

This alternative involves installation of ET caps on RAs (and in some instances, parts of RAs) that have been identified in the SRI process as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater. As discussed in Section 3.0, ET caps, when combined with institutional controls that limit excavation through the cap, meet RCRA C and D technical standards and satisfy site RAOs for groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After grading to establish the appropriate cap slopes and stormwater drainage/collection, ET caps would be installed in the following RAs:

- RA-B: The furnace building, phos dock, secondary condenser, slag pit, and the P4-impacted capillary fringe down gradient of the furnace building (extended out to the outermost cap delineation borings);

- RA-C: The historical pond area (eastern portion) consisting of Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, and10S (extended out to the outermost cap delineation borings and excluding the capped Pond 8S). and the former Pond 8S recovery process location (RU 13);

- RA-D: The historical pond area (western portion) consisting of Ponds 9S, 1E, 2E, 3E, 4E, 5E, 6E, and 7E (extended out to the outermost cap delineation borings and excluding capped RCRA Ponds);

- RA-E: The ore kiln and calciner area (RU 8) plus the kiln overflow pond (in RU 9) (extended beyond the outermost cap delineation borings);

- Southern portion of RA-G: The calciner pond solids stockpile (southern portion of RU 16);

- RA-H: The construction debris landfill (RU 17) and the current plant landfill (RU-18); and

- The railroad swale (RU 22c) portion of RA-A.

5.2.2 Use of Gamma Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials, do not pose a threat to groundwater, and are not expected to be candidates for re-development. A gamma cap, with the appropriate institutional controls, satisfies site RAOs for potential human exposure pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust. These areas include:

- RA-F (except the northern tip): The slag and bullrock piles (RU 19) including the old solid waste landfill (RU 19b) and the railcars in the slag pile (RU 19c); and

- The northern two-thirds of RA-G: The dry process solids waste pile (RU 15).

5.2.3 Remediation Based Upon Future Site Re-Development

For other site areas that are candidates for re-development and that exceed RAOs only for human health endpoints for hypothetical future workers (primarily potential exposure to gamma radiation), remediation would be required at the time of site re-development, e.g., when land use and receptor exposure pathways are better defined so that appropriate remediation measures could be planned and incorporated into the site development. These areas include:

- RA-A (except for the railroad swale): Former office areas, (RUs 3, 4, and 5), long-term P4 storage (RU 6), parking areas, railroad siding (RU 24), ore stockpiles (RU 7), silica stockpile (RU 9), and Bannock Paving area (RU 20). Note that the eastern portion of RA-A (on State land) is included in the PCDA Development Agreement.

- The northern tip of RA-F: RU 11 and the southern portion of RU 12.

5.2.4 Sub-Area Remediation

Underground Piping - Under this alternative, all P4 areas (including P4 associated with underground piping) would be under ET Caps, with the exception of the potential P4 residues in underground storm sewer piping in RU 3. These 16-inch, reinforced concrete sewer pipes would be cleaned to remove potential residual P4 and soil/materials potentially containing metal and radiological constituents as part of the Remedial Action. These sewers will remain in place for continued stormwater management.

Hydrocarbon Impacted Soil (portions of RU 20) – The soil impacted by hydrocarbons would not be addressed under this alternative. Future land use would determine the remediation of this fuel-impacted area, as necessary.

Coke (Portions of RU 20) – The soil impacted by coke in the southern portion of RU 20 would not be addressed under this alternative. Future land use would determine the remediation of this coke-impacted area, as necessary.

5.2.5 Achievement of RAOs

This assembled alternative meets all of the RAOs, noting that RA-A (except the railroad swale) and the northern tip of RA-F rely on institutional controls until re-development occurs (e.g., deed restrictions that prevent change in land use that could change current exposure scenarios). At that time, the development planning process would have to address remedial actions based upon the site receptors and the type of development taking place to ensure RAOs continue to be met. Agency approval of remedial and redevelopment plans would be stipulated as a requirement in deed restrictions.

5.3 ASSEMBLED SOIL ALTERNATIVE 3 (SEE FIGURE 2)

5.3.1 Use of ET Caps

As in Alternative 2, this alternative involves installation of ET caps on RAs (and in some instances, parts of RAs) that have been identified in the SRI process as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater. As discussed in Section 3.0, ET caps, when combined with institutional controls that limit excavation through the cap, meet RCRA C and D technical standards and satisfy site RAOs for groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After grading to establish the appropriate cap slopes and stormwater drainage/collection, ET caps would be installed in the following RAs:

- RA-B: The furnace building, phos dock, secondary condenser, slag pit, and the P4-impacted capillary fringe down gradient of the furnace building (extended out to the outermost cap delineation borings);

- RA-C: The historical pond area (eastern portion) consisting of Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, and10S (extended out to the outermost cap delineation borings and excluding the capped Pond 8S). and the former Pond 8S recovery process location (RU 13);

- RA-D: The historical pond area (western portion) consisting of Ponds 9S, 1E, 2E, 3E, 4E, 5E, 6E, and 7E (extended out to the outermost cap delineation borings and excluding capped RCRA Ponds);

- RA-E: The ore kiln and calciner area (RU 8) plus the kiln overflow pond (in RU 9) (extended beyond the outermost cap delineation borings);

- Southern portion of RA-G: The calciner pond solids stockpile (southern portion of RU 16);

- RA-H: The construction debris landfill (RU 17) and the current plant landfill (RU-18);

- The railroad swale (RU 22c) portion of RA-A;

- The old solid waste landfill (RU 19b) under the northwestern corner of the slag pile; and

- The railcars buried (RU 19c) under the center of the slag pile.

5.3.2 Use of Gamma Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials but do not pose a threat to groundwater. A gamma cap, with the appropriate institutional controls, satisfies site RAOs for protection against potential human exposure pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust. These areas include:

- RA-A (except for railroad swale): Former office areas, (RUs 3, 4, and 5), long-term P4 storage (RU 6), parking areas, railroad siding (RU 21), ore stockpiles (RU 7), silica stockpile (RU 9), and Bannock Paving area (RU 20). Note that the eastern portion of RA-A (on State land) is included in the PCDA Development Agreement.

- RA-F: The slag and bullrock piles (RU 19 except for RUs 19b and 19c); and

- The northern two-thirds of RA-G: The dry process solids waste pile (RU 15).

Future land use changes and site re-development in these areas at a future time would need to be considered in development of deed restrictions as the site redevelopment could require the disturbance the gamma caps.

5.3.3 Sub-Area Remediation

Underground Piping - Under this alternative, all P4 areas (including P4 associated with underground piping) would be under ET Caps, with the exception of the potential P4 residues in underground storm sewer piping in RU 3. These 16-inch, reinforced concrete sewer pipes would be cleaned to remove potential residual P4 and soil/materials potentially containing metal and radiological constituents as part of the Remedial Action. These sewers will remain in place for continued stormwater management.

Hydrocarbon Impacted Soil (portions of RU 20) – The soil impacted by hydrocarbons would be addressed by inclusion in the RA-A gamma cap.

Coke (Portions of RU 20) – The soil impacted by coke in the southern portion of RU 20 would be addressed by inclusion in the RA-A gamma cap.

5.3.4 Achievement of RAOs

This assembled alternative meets all of the RAOs.

5.4 ASSEMBLED SOIL ALTERNATIVE 4 (SEE FIGURE 3)

5.4.1 Excavation and Consolidation

Unlike previous alternatives, this alternative involves excavation of some limited areas of the site down to native soil and consolidation of site fill materials from some RAs (or portions of RAs) to be incorporated under caps in other RAs. The areas targeted for excavation and consolidation are those that include shallow fill and that have not been identified in the SRI process as posing a risk to groundwater. The location and placement of the excavated fill will be determined by the final grading plan. With removal of the fill materials down to native soil, which does not further contain significant quantities of leachable COCs, the RAOs will have been met. Confirmation sampling of the underlying native soil in excavated areas will be performed to demonstrate that the RAOs are met. It should be noted that on a cost basis, removal of 2 feet of fill material is the approximate break-even point when compared to installing a gamma cap. In this alternative, the following RAs would have some fill material removed and consolidated under a cap at another RA on site:

- RA-A (except for railroad swale): Former office areas, (RUs 3, 4, and 5), long-term P4 storage (RU 6), parking areas, railroad siding (RU 21), the northern portion of the Bannock Paving area (RU 20); and

- The northern two-thirds of RA-G: The dry process solids waste pile (RU 15).

5.4.2 Use of Multi-layer Caps

Unlike Alternatives 2 or 3, this alternative involves installation of multi-layer caps on RAs (and in some instances, parts of RAs) that pose a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater. As discussed in Section 3.0, multi-layer caps, when combined with institutional controls that limit excavation through the cap, meets the site RAOs for groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After grading to establish the appropriate cap slopes and stormwater drainage/collection, multi-layer caps would be installed in the following RAs:

- RA-B: The furnace building, phos dock, secondary condenser, slag pit, and the P4-impacted capillary fringe down gradient of the furnace building (extended out to the outermost cap delineation borings);

- RA-C: The historical pond area (eastern portion) consisting of Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, and10S (extended out to the outermost cap delineation borings and excluding the capped Pond 8S). and the former Pond 8S recovery process location (RU 13);

- RA-D: The historical pond area (western portion) consisting of Ponds 9S, 1E, 2E, 3E, 4E, 5E, 6E, and 7E (extended out to the outermost cap delineation borings and excluding capped RCRA Ponds);

- RA-E: The ore kiln and calciner area (RU 8) plus the kiln overflow pond (in RU 9) (extended beyond the outermost cap delineation borings);

- Southern portion of RA-G: The calciner pond solids stockpile (southern portion of RU 16);

- RA-H: The construction debris landfill (RU 17) and the current plant landfill (RU-18);

- The railroad swale (RU 22c) portion of RA-A;

- The old solid waste landfill (RU 19b) under the northwestern corner of the slag pile; and

- The railcars buried (RU 19c) under the center of the slag pile.

5.4.3 Use of Gamma Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials, but have not been identified in the SRI process as posing a threat to groundwater. A gamma cap, with the appropriate institutional controls, satisfies site RAOs for protection against potential human exposure pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust. These areas include:

- Eastern portion of RA-A (except for railroad swale): The ore stockpiles (RU 7) and the northern portion of the silica stockpile (RU 9). Note that the eastern portion of RA-A (on State land) is included in the PCDA Development Agreement.

- RA-F: The slag and bullrock piles (RU 19 except for RUs 19b and 19c); and

- The southwestern portion of RA-A: The southern portion of Bannock Paving (RU 20).

Future land use changes and site re-development in these areas at a future time would need to be considered in development of deed restrictions as the site redevelopment could require the disturbance the gamma caps.

5.4.4 Sub-Area Remediation

Underground Piping - Under this alternative, all P4 areas (including P4 associated with underground piping) would be under a multi-layer cap, with the exception of the potential P4 residues in underground storm sewer piping in RU 3. These 16-inch, reinforced concrete sewer pipes would be cleaned to remove potential residual P4 and soil/materials potentially containing metal and radiological constituents as part of the Remedial Action. These sewers will remain in place for continued stormwater management.

Hydrocarbon Impacted Soil (portions of RU 20) – The soil impacted by hydrocarbons would be addressed by landfarming in-place.

Coke (Portions of RU 20) – The soil impacted by coke in the southern portion of RU 20 would be addressed by inclusion in the RA-A gamma cap.

5.4.5 Achievement of RAOs

This assembled alternative meets all of the RAOs.

5.5 ASSEMBLED SOIL ALTERNATIVE 5 (SEE FIGURE 4)

5.5.1 Excavation and Consolidation

This alternative involves excavation of some limited areas of the site down to native soil and consolidation of site fill materials from some RAs (or portions of RAs) to be incorporated under caps in other RAs. The areas targeted for excavation and consolidation are those that include shallow fill and that have not been identified in the SRI process as posing a risk to groundwater. The location and placement of the excavated fill will be determined by the final grading plan. With removal of the fill materials down to native soil, which does not further contain significant quantities of leachable COCs, the RAOs will have been met. Confirmation sampling of the underlying native soil in excavated areas will be performed to demonstrate that the RAOs are met. It should be noted that on a cost basis, removal of 2 feet of fill material is the approximate break-even point when compared to installing a gamma cap. In this alternative, the following RAs would have fill material removed and consolidated under a cap at another RA on site:

- RA-A (except for railroad swale): Former office areas, (RUs 3, 4, and 5), long-term P4 storage (RU 6), parking areas, railroad siding (RU 21), the northern portion of the Bannock Paving area (RU 20); and

- The center third of RA-G: The calciner pond solids which would be consolidated under the RA-G ET cap.

5.5.2 Excavation and Treatment Off-Site

This alternative involves excavation to remove certain shallow P4-impacted soils down to 10 feet. As the alternative does not include on-site treatment, the P4 and excavated soil would be containerized in 55-gallon drums and shipped off-site to an approved commercial incinerator. Areas targeted for excavation of shallow P4 impacted soils are those located in areas which would not otherwise require an ET or multi-layer cap were it not for the shallow P4-impacted materials. Conversely, areas which contain shallow P4-impacted soils within areas that have been identified in the SRI process as posing a risk to groundwater and thus would otherwise require an ET or multi-layer cap even after the P4 were removed, are not targeted for excavation. With removal of the P4-impacted soil down to 10 feet in targeted areas, the direct exposure P4 RAO will have been met in the excavated area. In this alternative, the following subareas would have P4-impacted soils removed and treated off-site:

- The railroad swale (RU 22c) portion of RA-A; and

- Underground piping in RA-C located in RU 24 between RUs 1 and 2 and RU 22b.

It should be noted that fill which does not contain P4 that overlie the P4-impacted areas will be removed, stockpiled for further testing, and segregated prior to managing P4 impacted soil/fill.

5.5.3 Use of Multi-layer Caps

This alternative involves installation of multi-layer caps on RAs (and in some instances, parts of RAs) that are known (or suspected) to have subsurface P4 and that pose a potential threat to groundwater due to the release and migration of COCs from surface/subsurface soil/fill to groundwater. As discussed in Section 3.0, multi-layer caps, when combined with institutional controls that limit excavation through the cap, meet site RAOs for protection of groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After grading to establish the appropriate cap slopes and stormwater drainage/collection, multi-layer caps would be installed in the following RAs:

- RA-B: The furnace building, phos dock, secondary condenser, slag pit, and the P4-impacted capillary fringe down gradient of the furnace building (extended out to the outermost cap delineation borings);

- RA-C: The historical pond area (eastern portion) consisting of Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, and10S (extended out to the outermost cap delineation borings and excluding the capped Pond 8S) and the former Pond 8S recovery process location (RU 13), but excluding the piping corridor in RU 24 that will be excavated;

5.5.4 Use of ET Caps

This alternative involves installation of ET caps on RAs (and in some instances, parts of RAs) that have been identified in the SRI process as posing a potential threat to groundwater due to release and migration of COCs from surface/subsurface soil/fill to groundwater (but are not known or suspected to contain P4). As discussed in Section 3.0, ET caps, when combined with institutional controls that limit excavation through the cap, meet RCRA C and D technical standards and satisfy site RAOs for protection of groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After grading to establish the appropriate cap slopes and stormwater drainage/collection, ET caps would be installed in the following RAs:

- RA-D: The historical pond area (western portion) consisting of Ponds 9S, 1E, 2E, 3E, 4E, 5E, 6E, and 7E (extended out to the outermost cap delineation borings and excluding capped RCRA Ponds);

- RA-E: The ore kiln and calciner area (RU 8) plus the kiln overflow pond (in RU 9) (extended beyond the outermost cap delineation borings);

- Southern portion of RA-G: The calciner pond solids stockpile (southern portion of RU 16);

- RA-H: The construction debris landfill (RU 17) and the current plant landfill (RU-18);

- The old solid waste landfill (RU 19b) under the northwestern corner of the slag pile; and

- The railcars buried (RU 19c) under the center of the slag pile.

5.5.5 Use of Gamma Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials but have not been identified as posing a threat to groundwater. A gamma cap, with the appropriate institutional controls, satisfies site RAOs for protection against potential human exposure pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust. These areas include:

- Eastern portion of RA-A (except for railroad swale): The ore stockpiles (RU 7) and the northern portion of the silica stockpile (RU 9). Note that the eastern portion of RA-A (on State land) is included in the PCDA Development Agreement;

- The southwestern portion of RA-A: The southern portion of Bannock Paving (RU 20); and

- RA-F: The slag and bullrock piles (RU 19 except for RUs 19b and 19c).

Future land use changes and site re-development in these areas at a future time would need to be considered in development of deed restrictions as the site redevelopment could require disturbance of the gamma caps.

5.5.6 Sub-Area Remediation

<u>Underground Piping</u> - Under this alternative, all P4 areas (including P4 associated with underground piping) would be under a multi-layer cap, with the exception of those areas in which the P4 is removed and treated off-site (i.e., the railroad swale, the underground storm sewers in RU 3, and the underground piping in the piping corridor in RU 24).

Hydrocarbon Impacted Soil (portions of RU 20) – The soil impacted by hydrocarbons would be addressed by landfarming in-place.

Coke (Portions of RU 20) – The soil impacted by coke in the southern portion of RU 20 would be addressed by inclusion in the RA-A gamma cap.

5.5.7 Achievement of RAOs

This assembled alternative meets all of the RAOs.

5.6 ASSEMBLED SOIL ALTERNATIVE 6 (SEE FIGURE 5)

5.6.1 Excavation and Consolidation

This alternative involves excavation of some limited areas of the site down to native soil and consolidation of site fill materials from some RAs (or portions of RAs) to be incorporated under caps in other RAs. The areas targeted for excavation and consolidation are those that include shallow fill and that have not been identified in the SRI process as posing a risk to groundwater. The location of the placement of the excavated fill will be determined by the final grading plan. With removal of the fill materials down to native soil, which does not further contain significant quantities of leachable COCs, the RAOs will have been met. Confirmation sampling of the underlying native soil in excavated areas will be performed to demonstrate that the RAOs are met. It should be noted that on a cost basis, removal of 2 feet of fill material is the approximate break-even point when compared to installing a gamma cap. In this alternative, the following RAs would have fill material removed and consolidated under a cap at another RA on site:

- RA-A (except for railroad swale): Former office areas, (RUs 3, 4, and 5), long-term P4 storage (RU 6), parking areas, railroad siding (RU 21), the northern portion of the Bannock Paving area (RU 20); and

- The northern two-thirds of RA-G: The dry process solids waste pile (RU 15) which would be consolidated under the RA-G ET cap.

5.6.2 Excavation and Treatment On-Site

This alternative involves excavation to remove P4 contaminated soils down to 10 feet bgs, even in areas which will still require an ET or multi-layer cap so as to achieve the RAO to reduce the release and migration of COCs to groundwater. As this alternative includes on-site treatment using caustic hydrolysis, the excavated soil would be prepared by sizing and mixing to provide a uniform feed. With removal of the P4-impacted soil down to 10 feet, the direct exposure P4 RAO will have been met in the excavated areas. In this alternative, the following RAs would have P4-impacted soils removed and treated on-site:

- The railroad swale (RU 22c) portion of RA-A;

- All underground piping containing P4;

- RA-B: The furnace building, phos dock, secondary condenser, (RU 1) and slag pit (RU 2);

- RA-C: The historical pond area (eastern portion), and the former Pond 8S recovery process location (RU 13).

It should be noted that fill that does not contain P4 that may overlie P4-impacted areas will be removed, stockpiled for further testing, and segregated prior to managing P4 impacted soil/fill.

5.6.3 Use of Multi-layer Caps

This alternative involves installation of multi-layer caps on RAs (and in some instances, parts of RAs) that are known (or suspected) to have subsurface P4 and that pose a potential threat to groundwater due to the release and migration of COCs from surface/subsurface soil/fill to groundwater. A multi-layer cap would be used on areas where the P4 was excavated down to 10 feet bgs, backfilled, and where P4 or other COCs which have been identified as potentially impacting groundwater are known or suspected to remain below the 10-foot excavation depth. As discussed in Section 3.0, multi-layer caps, when combined with institutional controls that limit excavation through the cap, meet site RAOs for protection of groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After excavation of P4 down to 10 feet bgs and grading to establish the appropriate cap slopes and stormwater drainage/collection, multi-layer caps would be installed in the following RAs:

- RA-B: The furnace building, phos dock, secondary condenser, slag pit, and the P4-impacted capillary fringe down gradient of the furnace building (extended out to the outermost cap delineation borings);

- RA-C: The historical pond area (eastern portion) consisting of Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, and10S (extended out to the outermost cap delineation borings and excluding the capped Pond 8S). and the former Pond 8S recovery process location (RU 13), but excluding the piping corridor in RU 24 that will be excavated;

- The railcars buried (RU 19c) under the center of the slag pile.

5.6.4 Use of ET Caps

This alternative involves installation of ET caps on RAs (and in some instances, parts of RAs) that pose a potential threat to groundwater due to the release and migration of COCs from surface/subsurface soil/fill to groundwater (but are not known or suspected to contain P4). As discussed in Section 3.0, ET caps, when combined with institutional controls that limit excavation through the cap, meet RCRA C and D technical standards and satisfy site RAOs for protection of groundwater as well as protection against potential human exposure pathways including: 1) gamma radiation emission, 2) incidental ingestion, 3) direct dermal exposure, 4) threat to P4 fire, and 5) inhalation of fugitive dust. After grading to establish the appropriate cap slopes and stormwater drainage/collection, ET caps would be installed in the following RAs:

- RA-D: The historical pond area (western portion) consisting of Ponds 9S, 1E, 2E, 3E, 4E, 5E, 6E, and 7E (extended out to the outermost cap delineation borings and excluding capped RCRA Ponds);

- RA-E: The ore kiln and calciner area (RU 8) plus the kiln overflow pond (in RU 9) (extended beyond the outermost cap delineation borings);

- Southern portion of RA-G: The calciner pond solids stockpile (southern portion of RU 16);

- RA-H: The construction debris landfill (RU 17) and the current plant landfill (RU-18); and

- The old solid waste landfill (RU 19b) under the northwestern corner of the slag pile.

5.6.5 Use of Gamma Caps

After grading to establish the appropriate cap slopes and stormwater drainage/collection, a gamma cap would be placed on those areas that are covered by fill materials, but have not been identified as posing a threat to groundwater. A gamma cap, with the appropriate institutional controls, satisfies site RAOs for protection against potential human exposure pathways for: 1) gamma radiation, 2) incidental ingestion, 3) direct dermal exposure, and 4) inhalation of fugitive dust. These areas include:

- Eastern portion of RA-A (except for railroad swale): The ore stockpiles (RU 7) and the northern portion of the silica stockpile (RU 9). Note that the eastern portion of RA-A (on State land) is included in the PCDA Development Agreement;

- The southwestern portion of RA-A: The southern portion of Bannock Paving (RU 20); and

- RA-F: The slag and bullrock piles (RU 19 except for RUs 19b and 19c).

Future land use changes and site re-development in these areas at a future time would need to be considered in development of deed restrictions as the site redevelopment could require the disturbance of the gamma caps.

5.6.6 Sub-Area Remediation

Underground Piping - Under this alternative, all P4 areas (including P4 associated with underground piping) would be excavated and treated on-site (or off-site if not amenable to the on-site treatment process).

Hydrocarbon Impacted Soil (portions of RU 20) – The soil impacted by hydrocarbons would be addressed by landfarming in-place.

Coke (Portions of RU 20) – The soil impacted by coke in the southern portion of RU 20 would be addressed by inclusion in the RA-A gamma cap.

5.6.7 Achievement of RAOs

This assembled alternative meets all of the RAOs.

Table 4.1. Description of Remedial Areas (RAs) To Be Used in the SFS

Remedial Area	RUs	Description	Associated RCRA SWMUs [1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-A	3, 4, 5, 6, 7, northern portion of 9, 10, 20, 22c and 24	This area contains former office areas, parking areas, railroad siding, railroad swale, ore stockpiles, silica stockpile, laydown areas, and Bannock Paving area. Most of the remedial area is covered with non-leachable fill including primarily slag, ore, coke, silica, concrete, asphalt, and native soil. Underground piping containing COCs (including P4) exists in RU 3. Railroad swale (RU 22c) is known to contain low levels of P4. The eastern portion of RA-A (on State land) includes areas within the PCDA Development Agreement.	SWMU# 66 Boiler Fuel Tank and Pipeline Area SWMU# 72 Former Satellite Storage Area for Waste Paint Solvents SWMU# 92 P4 Maintenance Cleaning Facility (Decon Building) SWMU# 38 Road Segments SWMU# 99 Drum Storage Area at Training Center SWMU# 68 Railroad Spurs SWMU# 38 Road segments within RU 4 SWMU# 1 Drum Storage Unit SWMU# 39 Chemical Lab Drain Pit SWMU# 70 Satellite Storage Area for Spent Laboratory Solvents SWMU# 68 Railroad Spurs SWMU# 38 Road segments within RU 5 SWMU # 61 Laboratory Chemical Disposal Area SWMU# 63 Long-Term Phosphorus Storage Tanks (former) SWMU# 68 Railroad Spurs (portion within RU 6) SWMU# 101 Railcar Loading Overflow Tank SWMU# 37 Shale Ore Handling Areas SWMU# 105 Coke Unloading Building SWMU# 68 Railroad Spurs SWMU# 38 Road segments within RU 7 SWMU# 106 Nodule Pile SWMU# 49 Industrial Wastewater Basin SWMU# 50 Industrial Wastewater Ditch SWMU# 46 Railcar Loading and Unloading Area-BPC SWMU# 47 Bannock Paving Areas SWMU# 47 Coke Settling Pond (former BAPCO Unit) SWMU# 48 Surface roads Bannock Paving Company SWMU# 68 Railroad Spurs SWMU# 18 Railroad Swale	• Hypothetical future worker exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers <u>Subareas within RA-A that contain P4 (underground piping in RU 3 and the railroad swale):</u> • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. <u>Subareas within RA-A that contain P4 (underground piping in RU 3 and the railroad swale):</u> • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1.
RA-B	1, 2, and down gradient to include P4-impacted capillary fringe.	This area contains former locations of the furnace building, phossy dock, secondary condenser, and slag pit. Surface and/or subsurface fill within this remedial area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, concrete, asphalt, and silica. Underground piping containing COCs (including P4) exists in RUs 1 and 2.	SWMU# 13 Andersen Filter Media (AFM) Washing Unit SWMU# 41 (partial) Stacks and Vents SWMU# 54 Phos Dock Area SWMU# 36 & 55 Rail Car Loading/Unloading, and Phos Dock SWMU# 60 Secondary Condenser/Former Fluid Bec Dryer Area SWMU# 68 Railroad Spurs (portion within RU 1) SWMU# 73 Satellite Areas for Spent Anderson Filter Media SMWU# 74 East AFM Bin Area SMWU# 75 Precipitator Dust Slurry Pots SWMU# 76 Medusa Scrubber Blowdown Collection Tank SWMU# 77 P4 Loading Dock, Scrubber BlowdownSump, and NS Tank SWMU# 78 Washdown Collection Sumps--Furnace Building Area SWMU# 79 Northeast Collection Sump - Furnace Building Area SWMU# 80 Southeast Collection Sump - Furnace Building Area SWMU# 81 Furnace Washdown Collection Tank (V-3600) SWMU# 82 Facility-Wide Wastewater Piping System SWMU# 86 V-3700 Tank and Associated Piping SWMU# 90 V-3800 Tank and Associated Piping SWMU# 91 NOSAP Intercept Tank (Tank T-8010) SWMU# 104 #3 P4 Sump SWMU# 38 Road segments SWMU# 5 Slag Pit Wastewater Collection Sump SWMU#102 Former Slag Pit (prior to slag handling)	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.

Table 4.1. Description of Remedial Areas (RAs) To Be Used in the SFS

Remedial Area	RUs	Description	Associated RCRA SWMUs [1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-C	RUs 13, northern portion of 12, eastern portion of 22b, and a small portion of RU 24 between RUs 1 & 2 and RU 22b.	This area contains former phossy/precipitator slurry ponds, the piping corridor between RUs 1 and 2 and 22b (small portions of RUs 12 and 24), and the Pond 8S recovery process. Surface and/or subsurface fill within this area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, ferrophos, concrete and asphalt. Underground piping containing COCs (including P4) exists in RUs 13, 22b and 24.	SWMU# 64 (partial) Phossy Waste Pipeline Cleanout Areas SWMU# 65 (partial) Precipitator Slurry Pipeline Cleanout Areas SWMU# 82 (partial) Facility-wide Wastewater Piping System SWMU# 57 Transformer Salvage Area SWMU# 58 PCB Storage Shed (removed 2000) SWMU# 71 Satellite Storage Areas for Waste Degreasing Solvents SWMU# 83 High-pressure steam cleaning Station SWMU# 84 Used Oil Collection Tank SWMU# 38 Road Segments SWMU# 4 Former 8S Recovery Process SWMU# 107 Portable Storage Tanker for Dielectric Fluid SWMU# 25 Pond 0S SWMU# 26 Pond 00S SWMU# 27 Pond 1S SWMU# 28 Pond 2S SWMU# 29 Pond 3S SWMU# 30 Pond 4S SWMU# 31 Pond 5S SWMU# 32 Pond 6S SWMU# 33 Pond 7S SWMU# 34 Pond 10S (Including Precipitator Dust Pile atop pond 10S) SWMU# 43 Ferrophos Storage Areas SWMU# 53 Old Pond 7S Tree-Line Area SWMU# 56 Drum Storage Area for other Nonhazardous Wastes SWMU# 59 Waste Oil Storage Area SWMU# 62 Area West of Mobile Shop	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher. • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1.
RA-D	Western portion of 22b and Pond 9S	This area contains former clarified phossy water/precipitator slurry overflow ponds and precipitator slurry ponds. No P4 is present but surface/subsurface fill contains phossy solids, precipitator solids, slag, and ore.	SWMU# 6 Area 9S SWMU# 19 Pond 1E SWMU# 20 Pond 2E SWMU# 21 Pond 3E SWMU# 22 Pond 4E SWMU# 23 Pond 5E SWMU# 24 Pond 6E SWMU# 52 Pond 7E	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.

Table 4.1. Description of Remedial Areas (RAs) To Be Used in the SFS

Remedial Area	RUs	Description	Associated RCRA SWMUs [1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-E	RU 8 and southern portion of RU 9	This area contains former ore kilns, kiln scrubber ponds, calciners, silica stockpiles, and calcined ore stockpiles. No P4 is present but surface/subsurface fill contains slag, ore, silica, kiln pond solids (subsurface). Underground piping containing COCs (including P4) exists in RU 8.	SWMU# 12 Wastewater Treatment Unit SWMU# 35 Three kiln Scrubber Ponds SWMU# 67 Former Flare Pit for Carbon Monoxide SWMU# 41 Stacks and Vents (i.e., calciner system) SWMU# 103 New Horizontal Flare Pit SWMU# 38 Road Segments within RU 8 SWMU# 51 Kiln (scrubber) Overflow Pond (under nodule fines pile)	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers <u>Subareas within RA-E that contain P4 (underground piping in RU 8):</u> • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher. <u>Subareas within RA-E that contain P4 (underground piping in RU 8):</u> • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1.
RA-F	RUs 19, 11, and southern portion of12	This area contains the slag pile and bullrock pile (RU 19) and former equipment maintenance/laydown areas (RUs 11 and 12). Surface and subsurface fill within this area consists predominantly of slag and bull rock. Southwestern corner of slag pile was location of the former plant landfill. Railcars containing P4 and phossy solids are known to be buried in the slag pile (RU 19c).	SWMU# 42 Slag Pile SWMU# 44 Landfill (old) SWMU# 38 Segment of FMC surface road network	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.

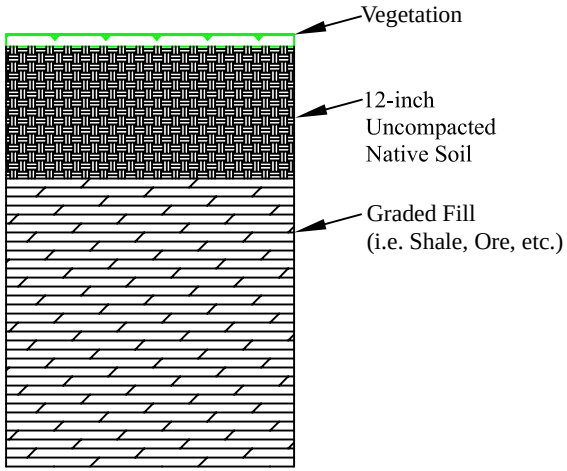
Table 4.1. Description of Remedial Areas (RAs) To Be Used in the SFS

Remedial Area	RUs	Description	Associated RCRA SWMUs [1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-G	RUs 15 and 16	This area contains the dry process waste pile (RU 15) and the calciner pond solids stockpile (RU 16). Surface and subsurface fill within this area include various plant solid materials including ore, baghouse dust, coke, carbon, calciner pond solids, and slag.	SWMU# 69 Oversize Ore, Broken and Used Electrode, Baghouse Dust Storage and Recycling, and Used Conveyor Belt Area SWMU# 38 Road segments SWMU# 16 Calciner Solids Pile SWMU# 17 Calciner Pond Sediment Areas South of Calciner Ponds [SWMU 17= "Storage Area B"]	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.
RA-H	RUs 17 and 18	This area contains the active plant landfill (RU 18) and the construction/demolition debris landfill (RU 17). Surface and subsurface fill within this area contains solid waste including plant trash, Andersen filter media, asbestos, empty containers, concrete, carbon, and furnace feed materials (ore, silica, coke).	SWMU# 89 Roadway Landfill SWMU# 38 Road segments SWMU# 45 Landfill (also referred to as Solid Waste Landfill)	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1.
RA-I	Northern Properties (Parcels 1 and 2)	This area of the FMC Plant OU is north of Highway 30 and south of I-86. It was not used for plant production activities but was used for various agricultural, commercial and recreational activities. Some slag was applied to the surface for roads and parking.	None		
RA-J	Northern Properties (Parcels 3, 4, 5, and 6)	This area of the FMC Plant OU contains property north of Highway 30 and north of I-86 on State lands. It was not used for plant production activities but was used for various agricultural and commercial activities. Some slag was applied to surface for roads and parking. This property is within the PCDA Development Agreement.	None		

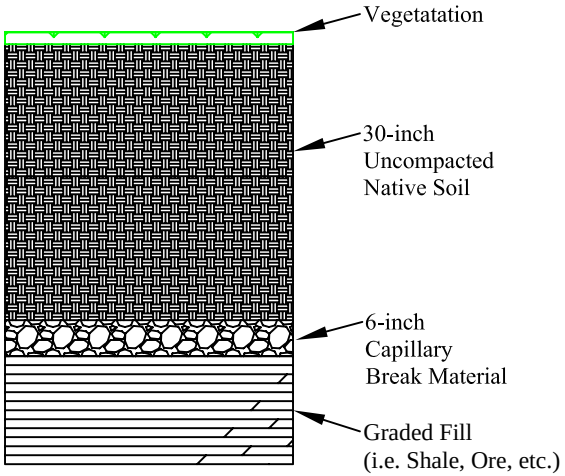
[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.

FILE *Fig 3.1 FMC_Caps_409.ai 5/1/09*

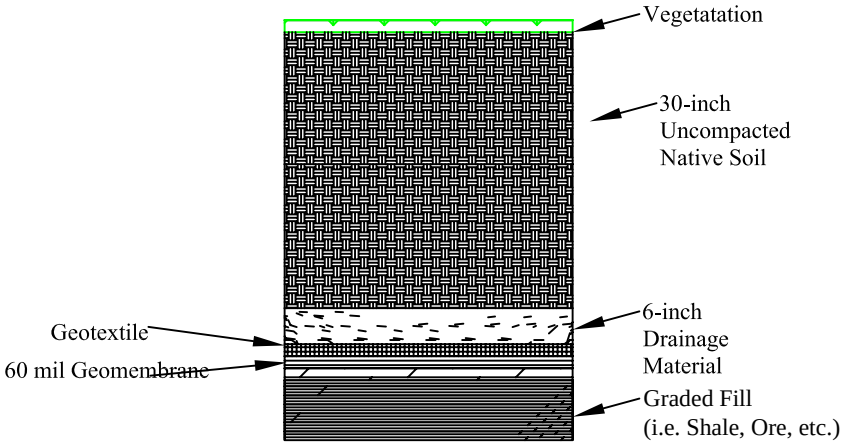
GAMMA CAP



ET CAP



MULTI-LAYERED CAP



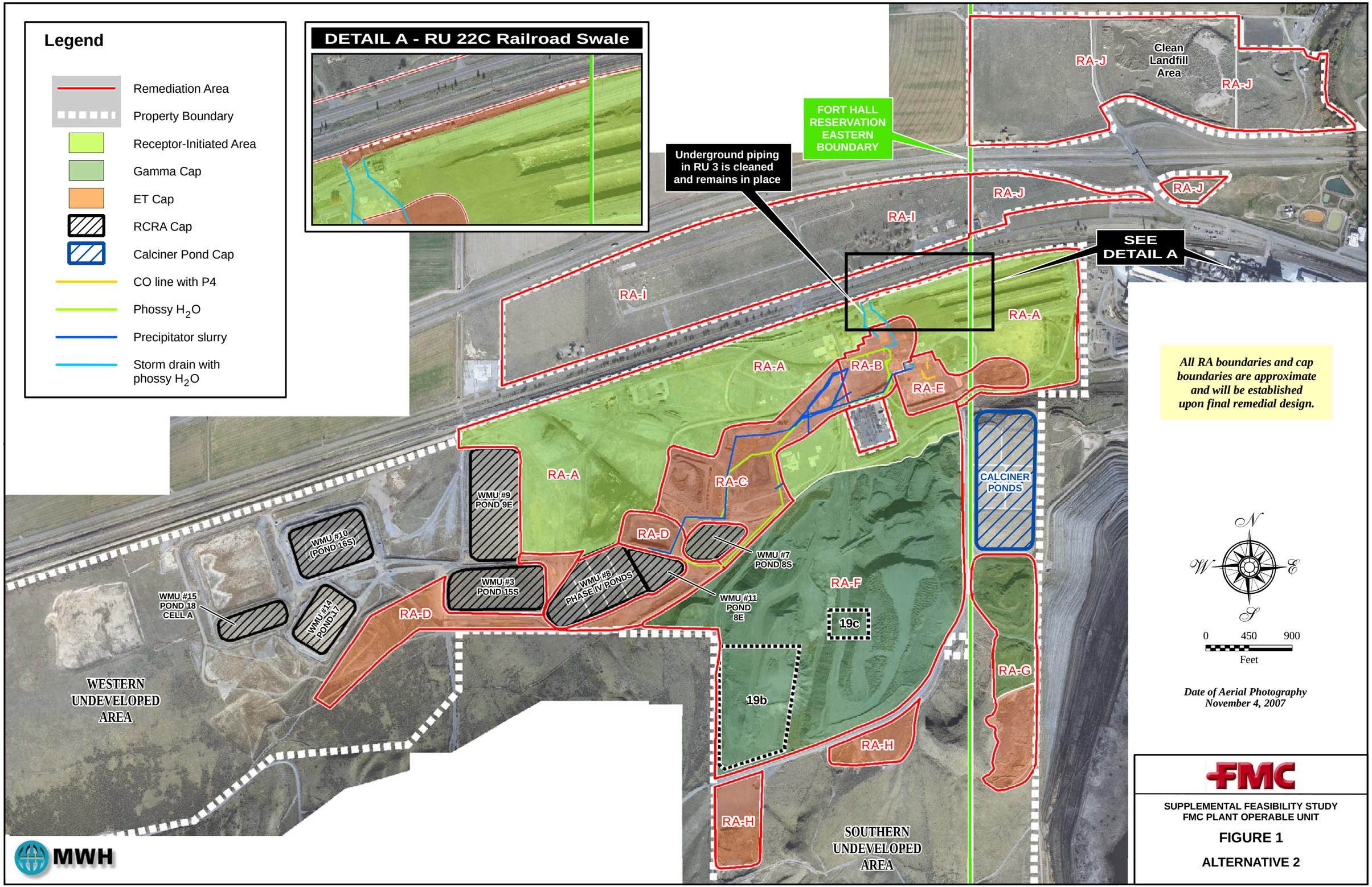
FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 3.1

CONCEPTUAL CAP DESIGNS

MWH


Legend
Remediation Area
Property Boundary
Receptor-Initiated Area
Gamma Cap
ET Cap
RCRA Cap
Calciner Pond Cap
CO line with P4
Phossy H_2O
Precipitator slurry
Storm drain with phossy H_2O
DETAIL A - RU 22C Railroad Swale
FORT HALL RESERVATION EASTERN BOUNDARY
Underground piping in RU 3 is cleaned and remains in place
SEE DETAIL A
Clean Landfill Area
RA-J
RA-I
RA-A
RA-B
RA-C
RA-D
RA-E
RA-F
RA-G
RA-H
CALCINER PONDS
WMU #9 POND 9E
WMU #10 (POND 16S)
WMU #3 POND 15S
WMU #8 PHASE IV PONDS
WMU #7 POND 8S
WMU #11 POND 8E
WMU #15 POND 18 CELL A
WMU #14 POND 17
19c
19b
WESTERN UNDEVELOPED AREA
SOUTHERN UNDEVELOPED AREA
All RA boundaries and cap boundaries are approximate and will be established upon final remedial design.
N
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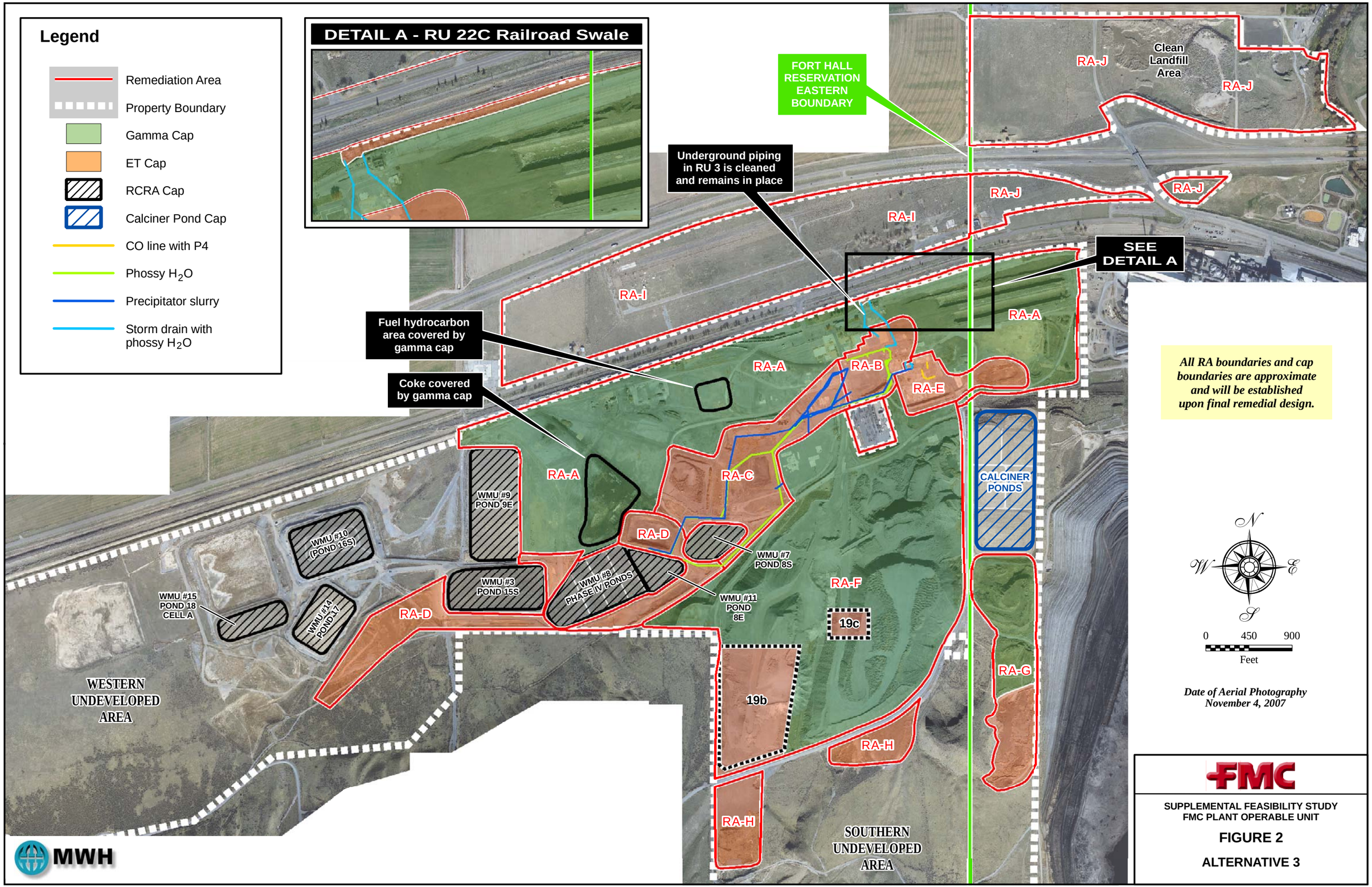
Feet
Date of Aerial Photography November 4, 2007
MWH
FMC
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 1
ALTERNATIVE 2
FILE Fig 1_FMC_ALTERNATIVE 2_509.mxd 4/30/09


Legend
Remediation Area
Property Boundary
Gamma Cap
ET Cap
RCRA Cap
Calciner Pond Cap
CO line with P4
Phossy H_2O
Precipitator slurry
Storm drain with phossy H_2O
DETAIL A - RU 22C Railroad Swale
FORT HALL RESERVATION EASTERN BOUNDARY
Underground piping in RU 3 is cleaned and remains in place
SEE DETAIL A
Fuel hydrocarbon area covered by gamma cap
Coke covered by gamma cap
RA-J
Clean Landfill Area
RA-I
RA-A
RA-B
RA-E
RA-C
RA-D
RA-F
RA-G
RA-H
WMU #9 POND 9E
WMU #10 (POND 16S)
WMU #3 POND 15S
WMU #8 PHASE IV PONDS
WMU #7 POND 8S
WMU #11 POND 8E
WMU #15 POND 18 CELL A
WMU #14 POND 17
19c
19b
CALCINER PONDS
WESTERN UNDEVELOPED AREA
SOUTHERN UNDEVELOPED AREA
All RA boundaries and cap boundaries are approximate and will be established upon final remedial design.
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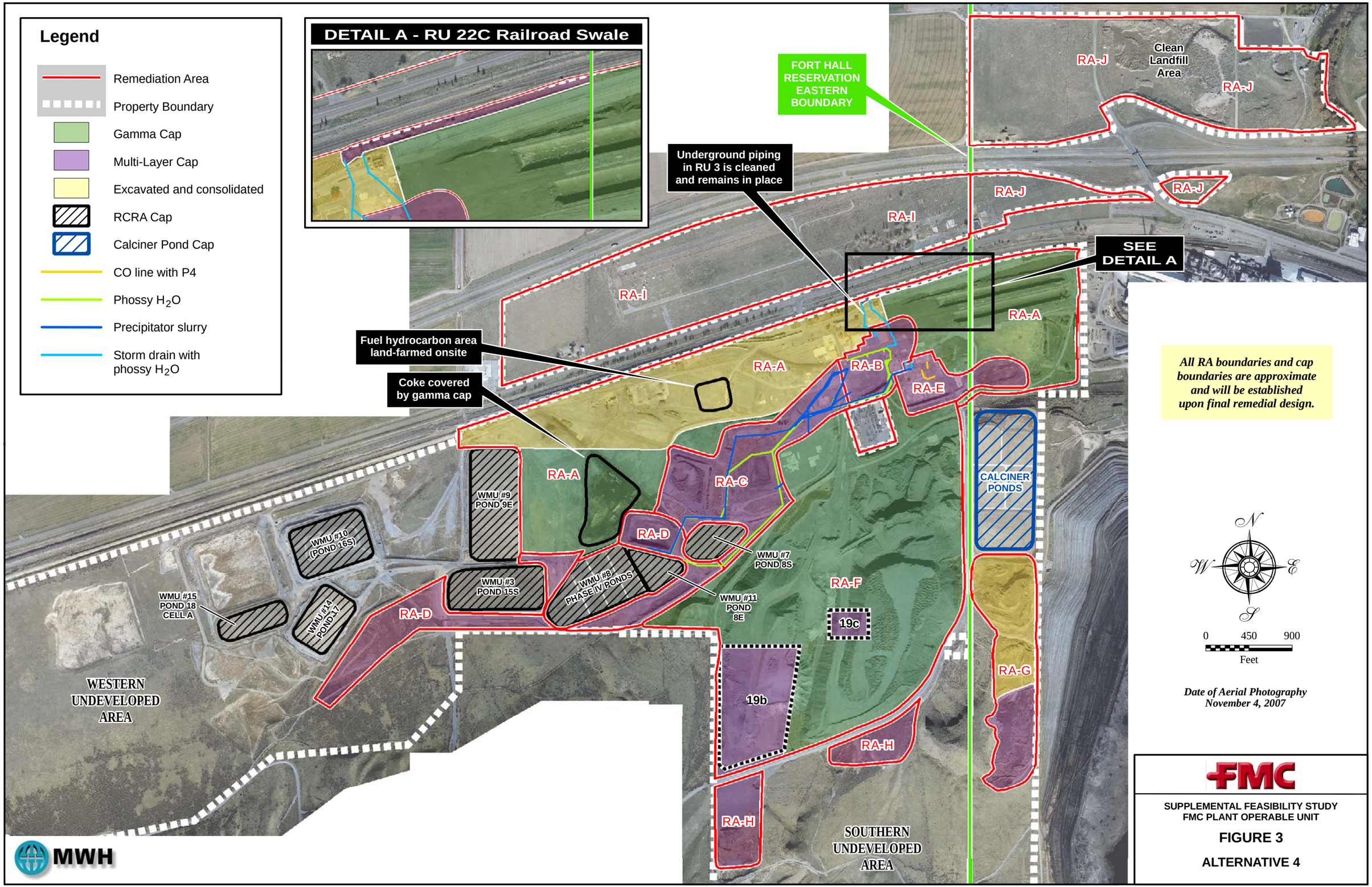
Date of Aerial Photography November 4, 2007
MWH
FMC
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 2
ALTERNATIVE 3
FILE Fig 2_FMC_ALTERNATIVE 3_509.mxd 5/05/09


Legend
Remediation Area
Property Boundary
Gamma Cap
Multi-Layer Cap
Excavated and consolidated
RCRA Cap
Calciner Pond Cap
CO line with P4
Phossy H_2O
Precipitator slurry
Storm drain with phossy H_2O
DETAIL A - RU 22C Railroad Swale
FORT HALL RESERVATION EASTERN BOUNDARY
Underground piping in RU 3 is cleaned and remains in place
SEE DETAIL A
Fuel hydrocarbon area land-farmed onsite
Coke covered by gamma cap
RA-J
Clean Landfill Area
RA-I
RA-A
RA-B
RA-E
RA-C
RA-D
RA-F
RA-G
RA-H
CALCINER PONDS
WMU #9 POND 9E
WMU #10 (POND 16S)
WMU #3 POND 15S
WMU #8 PHASE IV PONDS
WMU #7 POND 8S
WMU #11 POND 8E
WMU #15 POND 18 CELL A
WMU #14 POND 17
19c
19b
WESTERN UNDEVELOPED AREA
SOUTHERN UNDEVELOPED AREA
All RA boundaries and cap boundaries are approximate and will be established upon final remedial design.
N
W
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450
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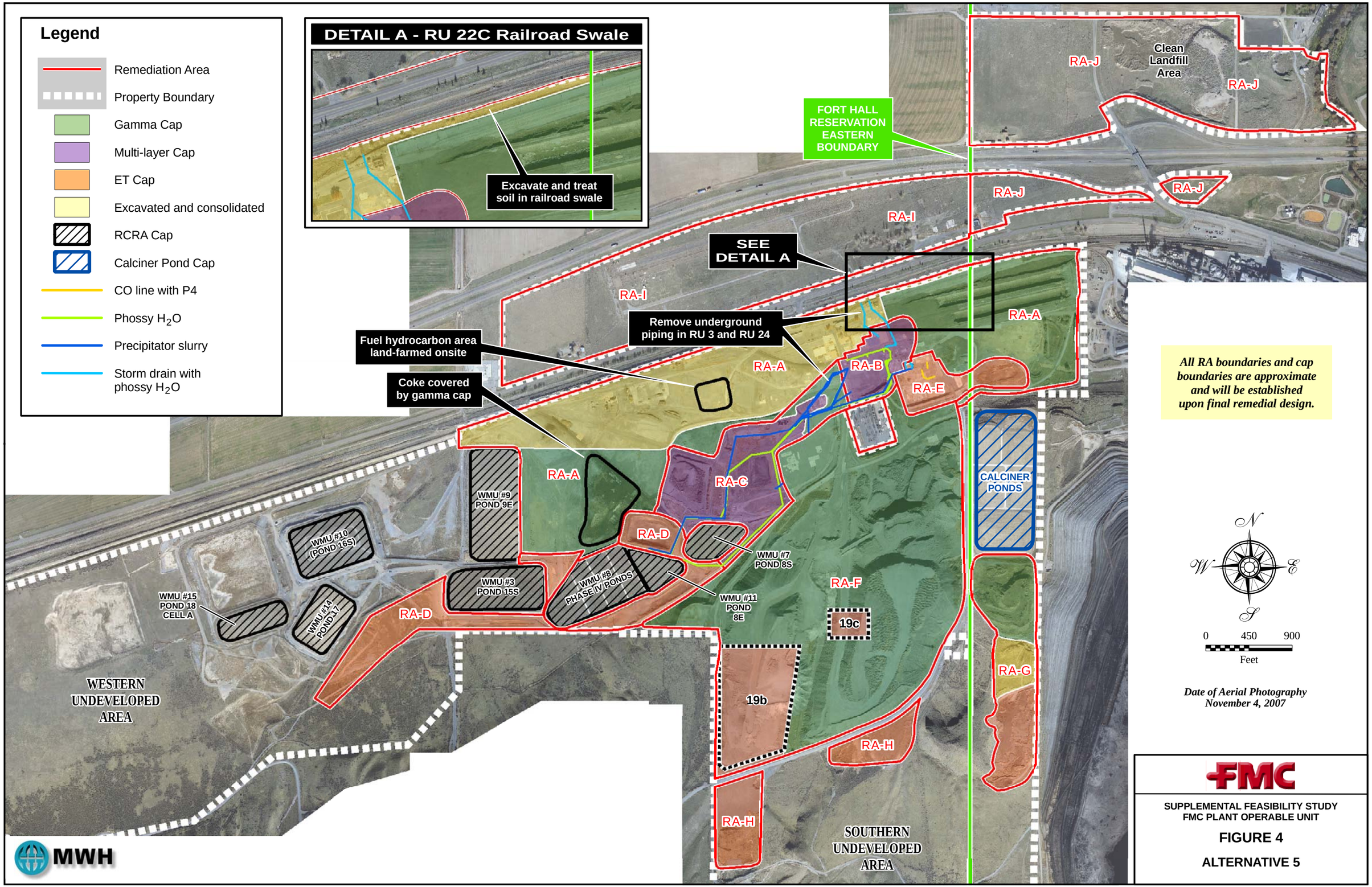
Feet
Date of Aerial Photography November 4, 2007
MWH
FMC
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 3
ALTERNATIVE 4
FILE Fig 3_FMC_ALTERNATIVE 4_509.mxd 5/05/09


Legend
Remediation Area
Property Boundary
Gamma Cap
Multi-layer Cap
ET Cap
Excavated and consolidated
RCRA Cap
Calciner Pond Cap
CO line with P4
Phossy H_2O
Precipitator slurry
Storm drain with phossy H_2O
DETAIL A - RU 22C Railroad Swale
Excavate and treat soil in railroad swale
FORT HALL RESERVATION EASTERN BOUNDARY
Clean Landfill Area
RA-J
RA-I
SEE DETAIL A
Remove underground piping in RU 3 and RU 24
Fuel hydrocarbon area land-farmed onsite
Coke covered by gamma cap
RA-A
RA-B
RA-E
RA-C
RA-D
RA-F
RA-G
RA-H
CALCINER PONDS
WMU #9 POND 9E
WMU #10 (POND 16S)
WMU #3 POND 15S
WMU #8 PHASE IV PONDS
WMU #7 POND 8S
WMU #11 POND 8E
WMU #15 POND 18 CELL A
WMU #14 POND 17
19c
19b
WESTERN UNDEVELOPED AREA
SOUTHERN UNDEVELOPED AREA
All RA boundaries and cap boundaries are approximate and will be established upon final remedial design.
N
W
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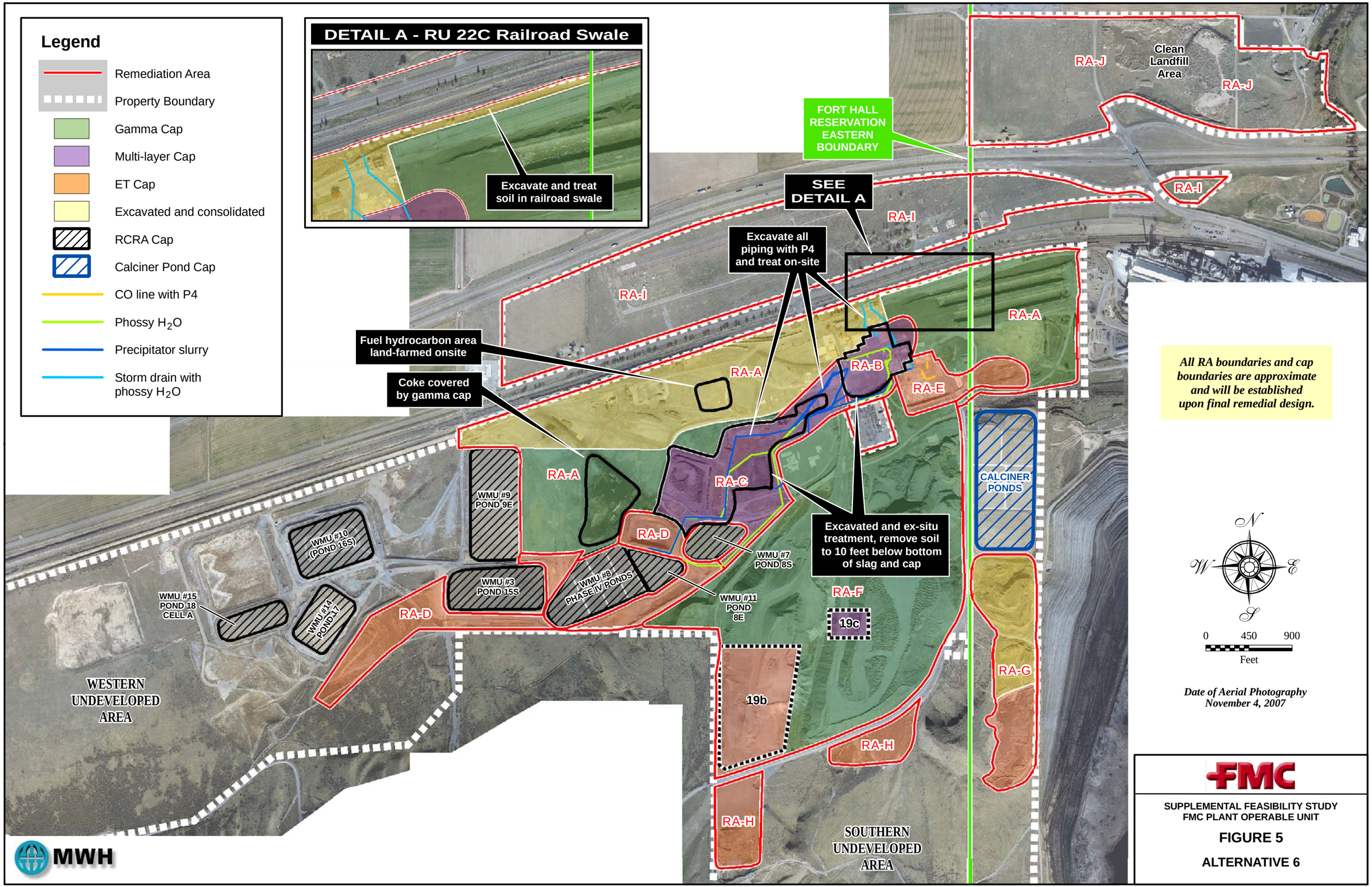
900
Feet
Date of Aerial Photography November 4, 2007
MWH
FMC
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 4
ALTERNATIVE 5
FILE Fig 4_FMC_ALTERNATIVE 5_509.mxd 4/30/09


Legend
Remediation Area
Property Boundary
Gamma Cap
Multi-layer Cap
ET Cap
Excavated and consolidated
RCRA Cap
Calciner Pond Cap
CO line with P4
Phossy H_2O
Precipitator slurry
Storm drain with phossy H_2O
DETAIL A - RU 22C Railroad Swale
Excavate and treat soil in railroad swale
FORT HALL RESERVATION EASTERN BOUNDARY
SEE DETAIL A
Excavate all piping with P4 and treat on-site
Fuel hydrocarbon area land-farmed onsite
Coke covered by gamma cap
Excavated and ex-situ treatment, remove soil to 10 feet below bottom of slag and cap
RA-J
Clean Landfill Area
RA-J
RA-I
RA-I
RA-I
RA-A
RA-A
RA-A
RA-B
RA-E
RA-C
RA-D
RA-D
RA-F
19c
19b
RA-H
RA-H
RA-G
CALCINER PONDS
WMU #9 POND 9E
WMU #10 (POND 16S)
WMU #3 POND 15S
WMU #8 PHASE IV PONDS
WMU #7 POND 8S
WMU #11 POND 8E
WMU #15 POND 18 CELL A
WMU #14 POND 17
WESTERN UNDEVELOPED AREA
SOUTHERN UNDEVELOPED AREA
MWH
All RA boundaries and cap boundaries are approximate and will be established upon final remedial design.
N
W
E
S
0
450
900
Feet
Date of Aerial Photography November 4, 2007
FMC
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 5
ALTERNATIVE 6
FILE Fig 5_FMC_ALTERNATIVE 6_509.mxd 4/30/09

Marc Bowman

From: Marc Bowman
Sent: Tuesday, June 16, 2009 11:21 AM
To: 'Lynch.Kira@epamail.epa.gov'
Cc: 'Douglas.Tanner@deq.idaho.gov'; 'Margaretha.English@deq.idaho.gov'; 'kwright@shoshonebannocktribes.com'; 'susanh@ida.net'; 'scott.miller@deq.idaho.gov'; 'BARBARA.RITCHIE@fmc.com'; 'davidh@SummitLaw.com'; Vance Drain; 'NGudka@Hanna-irm.com'; 'lhanna@hanna-irm.com'; 'greutert_ed@bah.com'; 'Stifelman.Marc@epamail.epa.gov'; 'poeton.rick@epamail.epa.gov'; 'zodrow.jean@epa.gov'; Leah Wolf-Martin; Rob Hartman
Subject: Interim SFS Deliverable - Capping Memo
Attachments: Cap Memo Complete (6-16-09) (E-mail).pdf

Kira:

On behalf of FMC, I am submitting the following Interim SFS Deliverables as discussed during our Seattle meeting on May 20-21, 2009:

- Capping Memo. As discussed during the Seattle meeting, the purpose of this memo is to present a comparison between conventional (multi-layer) and alternative (ET) capping systems. We had a phone discussion with Steve Rock on Friday, June 5, 2009 and discussed several capping issues with Steve. He gave us some good input and questions which we addressed in this memo.
- Technology selection by RA and Assembled Alternative Table. As you proposed during the Seattle meeting, we have prepared a table that identifies the potentially applicable process options for each Remediation Area, which then are used to assemble 3 soil alternatives for the FMC Plant OU. This has been a very useful exercise and should make the process more transparent to all interested parties. As you predicted, this screening has resulted in fewer total assembled alternatives than previously contemplated, e.g., three versus five in the May 5, 2009 initial submittal. We assume the assembled soil alternatives presented in this table will undergo the detail analysis in the SFS process. This submittal follows up on the revised Remediation Area (RA) Boundary Map and Revised Table 4.1 we sent to you on May 29, 2009. As you are aware, we had a phone discussion with Ed Gruetert of BAH on Thursday, June 11, 2005 to get his input on the revised RA boundaries. Following the useful input from Ed, we have made further minor modification to the RA descriptions as incorporated into this Interim Deliverable.

Due to the file size of these documents, the Technology Table will be forwarded to the route list in a separate email. Please feel free to contact me if you have any questions or have problems in downloading these files.

Thanks,

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FMC Idaho LLC, Pocatello, Idaho

Comparison of Conventional and Alternative Capping Systems for Use at the FMC Plant OU

June 2009

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ACRONYMS/ABBREVIATIONS

ACAP	Alternative Cover Assessment Program
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirements
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Center for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CO	carbon monoxide
COC	contaminant of concern
cm	centimeter
cm/sec	centimeter per second
DOE	United State Department of Energy
EMF	Eastern Michaud Flats
EPA	United States Environmental Protection Agency
ET	evapotranspiration
FLTF	Field Lysimeter Test Facility
FML	flexible membrane liner
FS	Feasibility Study
GCL	geosynthetic clay liner
GWCCR	Ground Water Current Conditions Report
HDPE	high-density polyethylene
LCDRS	leachate collection, detection, and removal system
m	meter
mm	millimeter
mm/yr	millimeter per year
NPL	National Priorities List
OU	Operable Unit
P4	elemental phosphorus
P	precipitation
pcf	pounds per cubic foot
PET	potential evapotranspiration
PH3	phosphine
RA	Remediation Area
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RU	Remediation Unit
SFS	Supplemental Feasibility Study
SRI	Supplemental Remedial Investigation
SRI/SFS	Supplemental Remedial Investigation Feasibility Study

ACRONYMS/ABBREVIATIONS

SWMU	Solid Waste Management Unit
TMP	Temperature Monitoring Point
UMTRCA	Uranium Mill Tailings Radiation Control Act
WP	white phosphorus
yr	year

SECTION 1.0 INTRODUCTION

Engineered cover systems are commonly constructed to cap waste materials and solids at municipal landfills, hazardous waste landfills, and mine waste repositories. The design of an engineered cover system is often an iterative process, involving the evaluation of several conceptual designs that may incorporate different soil layers and thicknesses, possibly involving the use of geosynthetic materials (e.g., a geomembrane). Conventional and alternative covers are the two general types of cover systems that are currently used to cap waste containment facilities or other impacted areas including those regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA).

Conventional (or regulatory guidance) cover systems are most frequently designed with one or more low permeability barrier layers consisting of fine grained soil (e.g., clay) or geosynthetic components (e.g. geosynthetic clay layer and/or flexible membrane liners). However, agency and industry concerns about the long-term durability of the geosynthetic components in conventional cover systems, long-term effectiveness and elevated costs associated with constructing these covers has led to the evaluation of various "alternative" cover designs. Compared to a conventional cover design, an alternative cover relies on increased water storage and establishment of native vegetation to increase evapotranspiration, rather than a low hydraulic conductivity layer(s) to minimize water movement through the cap and into the underlying waste material.

1.1 PURPOSE AND SCOPE OF THIS REPORT

This paper has been prepared to provide:

1) A general technical description of conventional and alternative cover systems relevant to the materials that are being considered for containment of identified waste areas at the FMC Plant Operable Unit (OU). Case studies of alternative cover systems are presented to provide the reader with an understanding of the various types of alternative covers that have been constructed and are currently in service on regulatory-directed remedial actions and closures.

2) An evaluation of the relevant and appropriate performance criteria for the cover systems to achieve the remedial action objectives (RAOs) for the waste areas the FMC Plant OU. These cap performance criteria are utilized to provide a comparative analysis of conventional and alternative cover systems.

3) A conceptual design of an alternative cover system that will be proposed as one of the capping process options in the Supplemental Feasibility Study (SFS) that is currently being prepared for the FMC Plant OU.

Specifically, this paper evaluates the efficacy of these two cover systems to facilitate the evaluation of remedial options at certain remediation areas (RAs) at the FMC Plant OU. The RAs to be evaluated by application of one of the two cover systems described in this white paper are those with identified releases of contaminants of concern (COCs) to groundwater as described in the *Groundwater Current Conditions Report* (*GWCCR*; MWH, 2009a) or those RAs that have the potential to impact groundwater based on results detailed in the *Supplemental Remedial Investigation Report for the FMC Plant OU* (*SRI Report*, MWH, 2009).

1.2 REGULATORY BACKGROUND

The FMC Plant OU is a part of the larger Eastern Michaud Flats (EMF) Superfund Site and is located in southeastern Idaho. The EMF Site was listed on the National Priorities List (NPL) on August 30, 1990. The EMF Site includes two adjacent production facilities, a former FMC Corporation elemental phosphorus processing plant that ceased operation in 2001 and a phosphate fertilizer processing facility operated by the J.R. Simplot Company (see Figure 1-1). The EMF Site encompasses both the FMC and Simplot plants and surrounding areas affected by releases from these facilities. FMC, Simplot and EPA entered into a CERCLA Administrative Order on Consent (AOC) in May 1991 under which the companies agreed to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the site. During the RI/FS the site was divided into three "Subareas:" 1) the FMC Subarea, consisting of the FMC Plant Site (where elemental phosphorus production took place) and other FMC-owned properties at the site; 2) the Simplot Subarea, consisting of the Simplot plant and other Simplot-owned properties at the site; and 3) the Off-Plant Subarea, consisting of the remainder of the site. EPA changed these designations to the FMC Plant OU, the Simplot Plant OU, and the Off-Plant OU after its June 1998 *Record of Decision for the EMF Site* (*1998 ROD*, EPA, 1998).

FMC ceased production of elemental phosphorus from phosphate ore at its Pocatello facility in December 2001. This led EPA and FMC to enter into an AOC in October 2003 for a Supplemental Remedial Investigation and Feasibility Study (SRI/SFS AOC) at the FMC Plant OU. This was driven primarily by EPA's finding that additional investigations and evaluations were needed at the plant areas that had been actively operated at the time of the RI/FS but where operations had terminated with the plant shutdown. The Supplemental Remedial Investigation (SRI) was performed during two periods:

- June through December 2007 that focused on the operating areas of the FMC Plant OU, and

- October through December of 2008 that focused on the FMC-owned properties on which operating activities were not conducted. These areas included the Southern Undeveloped Area, Western Undeveloped Area, and the Northern Properties located north of Highway 30.

1.3 FMC SITE DESCRIPTION AND OPERATIONAL HISTORY

1.3.1 FMC SITE DESCRIPTION

The FMC Plant Site is located approximately 2.5 miles northwest of Pocatello, Idaho, and 1 mile southwest of the Portneuf River, a tributary of the Snake River. The FMC Plant Site is south of Highway 30, covers approximately 1,150 acres, and historically contained all of the process operations used for the production of elemental phosphorus. There are an additional 212 acres owned by FMC located north of Highway 30 (the Northern Properties) that are also part of the FMC OU, but which have been determined to contain wind-blown surface deposition of process materials (primarily ore dust). The FMC Plant OU is on privately-owned fee land, most of which is located within the exterior boundaries of the Fort Hall Indian Reservation.

A more detailed description of the site's physical characteristics can be found in Section 2.0 of the *SRI Report*. Additional detailed information on the geology and hydrogeology of the EMF Site study area and the FMC Plant OU is presented in Sections 3.1 and 3.3, respectively, of the *EMF RI Report* (BEI, 1996), as well as Section 2.0 of the *GWCCR*.

1.3.2 HISTORIC FMC PLANT PROCESS DESCRIPTION

The FMC Plant Site produced elemental phosphorus (P4) from phosphate-bearing shale ore mined regionally. Ore was shipped to FMC via the Union Pacific Railroad during the summer months and stockpiled. The ore was crushed, screened, and formed into briquettes prior to heat treatment (known as calcining). The calcining process involved heating the ore briquettes to a sintering temperature of approximately 1,200°F to form nodules. Carbon monoxide (CO), a by-product of the phosphorus furnace reaction, was used as fuel to fire the calciners. The nodules were blended with coke and quartzite (known as silica) to make the phosphorus furnace feed. This mix of nodules, coke and silica was fed into four electric arc furnaces. A simple process flow diagram is shown in Figure 1-2.

The furnace reaction primarily yielded gaseous P4, CO gas, slag, and ferrophos. Slag and ferrophos were "tapped" out of the bottom of the furnace through tapping holes in a molten state. Once cooled, the ferrophos was stockpiled and sold intermittently for metal recovery. For most of the life of the plant, slag was allowed to cool and harden, then was loaded into haul trucks and either hauled to the slag pile or to Bannock Paving, also located on site. The P4 product was removed as a gas, along with CO gas, from the furnaces using vacuum pumps. This gas stream first passed through a pair of electrostatic precipitators, then through a water condenser that cooled the gas stream to below the P4 boiling point, thus condensing the P4 to a liquid. The liquid P4 collected in a sump in the furnace building floor. The liquid P4 was subsequently pumped to the phos dock where it was loaded into railcars for shipment. P4 will burn upon contact with air. Therefore, to prevent oxidation, the condensed phosphorus product was kept covered with water from the time it was produced through loading for transit off-site.

These two waste streams from the phosphorus manufacturing process also contained P4 and were thus managed as an aqueous slurry to prevent contact with air:

- Phossy water. This process stream consisted of process water that came into contact with P4, and therefore contained P4. Phossy water was processed at the phos dock to recover P4 and then pumped via pipelines to a series of surface impoundments to the west of the P4 manufacturing area. Here the suspended solids were allowed to settle in the surface impoundments and the clarified water was allowed to evaporate, or returned to the P4 manufacturing area.

- Precipitator slurry. Solids collected in the precipitators directly downstream of the phosphorus furnaces was slurried in water and pumped to a series of surface impoundments. These precipitator slurry surface impoundments were typically separate from the phossy water surface impoundments. The solids were allowed to settle, were eventually de-watered, and were re-processed for sale as a zinc-rich fertilizer additive.

Numerous surface impoundments (ponds) were used for management and disposal of these process waste streams. Many of these ponds were "closed" and covered with fill materials (primarily slag and ore materials) prior to applicability to RCRA hazardous waste regulation. These ponds, which are included in the scope of the CERCLA Supplemental Feasibility Study (SFS), include Ponds 00S, 0S, 1S, 2S, 3S, 4S, 5S, 6S, 7S, 9S, 10S, 1E, 2E, 3E, 4E, 5E, 6E and 7E.

Some of the waste management ponds, based upon the fact that they were "active" (i.e., were receiving process wastes) at the time RCRA hazardous waste regulations became applicable (or were constructed and put into use after that time), were designated as hazardous waste management units regulated under RCRA. A RCRA Consent Decree entered on July 13, 1999, required FMC, among other things, to close and cap such ponds that had not been closed as of that date in accordance with all applicable RCRA requirements and EPA-approved closure plans. These "RCRA" ponds included Ponds 8S, the Phase IV ponds (11S, 12S, 13S and 14S), 15S, 16S, 17, 18 (cells A and B), 8E, and 9E. Additional information on the cap design and operating experience for these closed RCRA ponds is provided in Section 2.4.3 of this report.

A more detailed description of the processes, ponds, and waste streams is provided in Section 1.0 of *Identification and Evaluation of P4 Treatment Technologies – January 2009* (MWH, 2009b).

1.4 DOCUMENT ORGANIZATION

The remainder of this Report consists of:

- Section 2.0: General technical description of conventional and alternative cover systems that are relevant at the FMC Plant OU. Case studies of alternative cover systems being utilized today are also presented.

- Section 3.0 An evaluation of the performance criteria that are necessary for the various cover systems to achieve the RAOs while in accordance with applicable or relevant and appropriate requirements (ARARs) that have been developed for the FMC Plant OU.

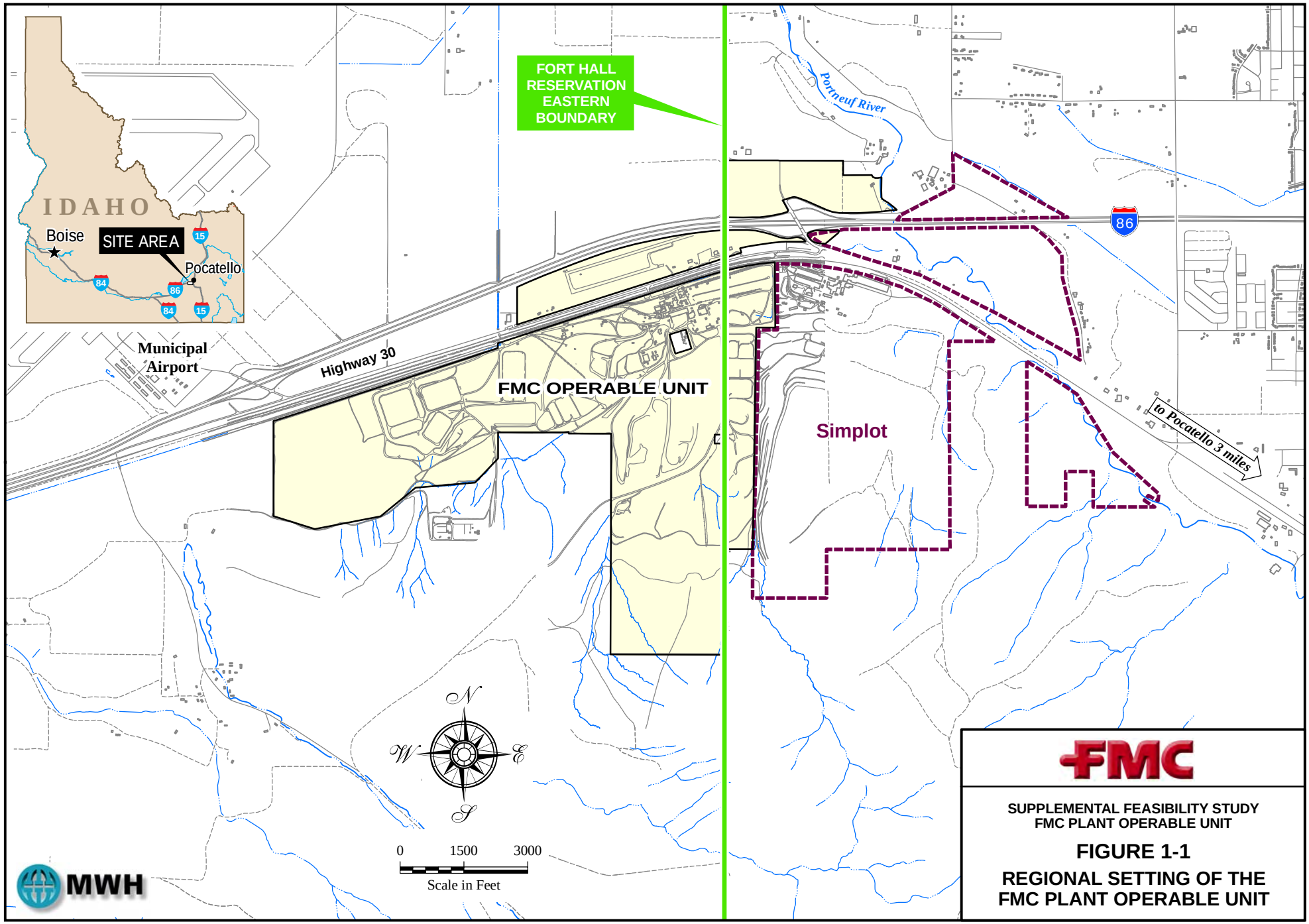
- Section 4.0 A conceptual design of an alternative cover system that will be proposed as one of the capping process options in the SFS.

- Appendix A: RCRA Design and Estimation of Percolation Rates Through the Pond 8S RCRA Cap (Appendix F to the *Pond 8S Closure Plan – May 1998*)

- Appendix B: Geotechnical Laboratory Results from the Cover/Cap Soil Borrow Area (Appendix D to the *Remedial Investigation Update Memorandum for the FMC Plant OU – June 2004*).

- Appendix C: Photographs of RCRA Pond Caps

FILE *Fig 1-01 Regional Setting_609.mxd* *6/15/09*

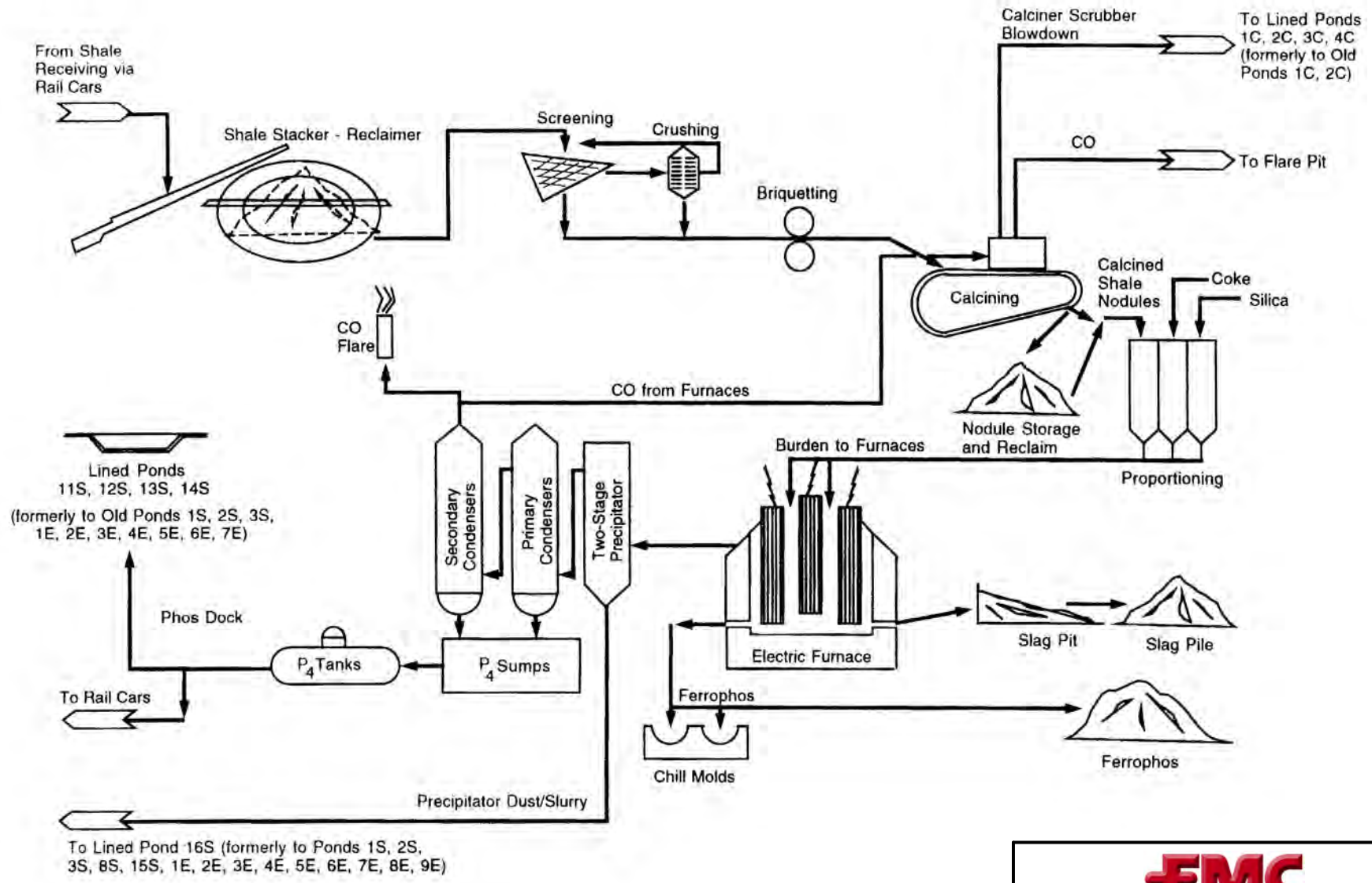


SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 1-1

REGIONAL SETTING OF THE FMC PLANT OPERABLE UNIT

FILE *Fig 1-02 FMC Flow diagram_609.ai 6/15/09*



NOTE "Old" ponds are those that are no longer operational.
SOURCE Taken from Figure 1.1-2 from EMF RI Report (BEI, 1996)

MWH

FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 1-2

FMC PLANT PROCESS FLOW DIAGRAM

SECTION 2.0 ENGINEERED COVER SYSTEMS

There are three distinctive types of caps being considered for remedial actions at the FMC Plant OU including:

- Gamma Cap;
- Evapotranspiration (ET) Cap; and
- Multi-layered Cap.

A schematic of these types of caps is shown in Figure 2-1. This section provides a technical description of conventional (multi-layered cap) and alternative (ET cap) covers. Gamma caps are not discussed in detail in this report because they are not generally installed to fulfill RAO requiring groundwater protection, but rather to fulfill the RAO for protection of site workers from gamma radiation. Their effectiveness in shielding gamma radiation has been discussed in Section 3.1 of the SFS interim deliverable entitled *Assembled Soil Alternatives for the FMC Plant OU – May 2009*. Note that properly vegetated gamma caps, with properly designed slopes to facilitate stormwater runoff will provide some level of groundwater protection beyond an uncapped area. In addition, case studies of alternative cover system are provided to give the reader an understanding of the various types of alternative covers currently being utilized to cover hazardous and radioactive wastes.

2.1 CONVENTIONAL (MULTI-LAYERED) COVERS

As mentioned previously, cover systems constructed at waste containment facilities have generally relied on a barrier or infiltration-control layer as the primary component to minimizing percolation into the underlying waste material and subsurface. The barrier layer installed in the cover will depend on the type of liner underlying the facility, but commonly includes a fine-grained layer of soil (e.g., clay) compacted to achieve a low saturated hydraulic conductivity (e.g., 1x10-7 cm/sec). In order to achieve a low hydraulic conductivity, the soils are placed and compacted in a wet condition (i.e., near to or above the optimum moisture content for the material). Conventional cover systems are required to meet design-based criteria by demonstrating that the material specifications (e.g., maximum hydraulic conductivity) for the barrier layer are being achieved. The material specification is linked to a performance-based standard (such as achieving a minimum infiltration rate through the cover) if hydraulic conductivity testing is conducted during or after construction.

The performance of the low-permeability soil layer is designed to meet material specifications (e.g., maximum hydraulic conductivity) through a comprehensive field and laboratory testing program. However, recent laboratory (e.g., Albrecht and Benson, 2001) and field investigations (e.g., Albright et al., 2006) have suggested that the high-

plasticity clays commonly used to construct the low-permeability layer are prone to desiccation and cracking, which may lead to significantly reduced performance. This is more common in arid and semiarid environments where the long-term ambient water content of the subsoil is lower than the typical optimum water content used for compaction. For example, the laboratory experiments reported by Albrecht and Benson (2001) demonstrated that specimens subjected to periodic wetting and drying experienced cracking which increased the hydraulic conductivity, sometimes as large as three orders of magnitude. Low-permeability soil layers constructed in covers located in arid and semiarid environments are especially prone to desiccation and cracking. In fact, at a test facility located in a semiarid environment near Albuquerque, New Mexico, Dwyer (2003) reported visible desiccation cracks in the compacted low-permeability layer within 15 minutes of installation.

To counteract design limitations of compacted soil barriers, a geomembrane may be installed above the low-permeability soil if a composite barrier system is required as part of the cover design. Theoretically, a geomembrane consists of an impermeable material that should preclude leakage into the underlying waste material. However, the occurrence of a limited number of manufacturing and installation defects (e.g., puncture holes or tears) is generally anticipated and incorporated during assessment of environmental impacts (Giroud and Bonaparte, 1989). Concern regarding the long-term durability of the geomembrane, in addition to the fine-grained low-permeability layer, and elevated costs associated with constructing a conventional cover with a composite barrier layer, has led to the evaluation of various alternative cap or cover designs.

2.2 ALTERNATIVE COVERS (ET COVERS)

Alternative cover systems are most commonly referred to as ET covers, but may be referred to as store-and-release, or water-balance, covers. An ET cover system relies on the hydraulic properties of the cover material to store water in the cap soil pore space for subsequent evaporation and transpiration. Water that migrates into the cover while plants are dormant is subsequently consumed through root-water uptake and evapotranspiration during the growing season. The vegetation is expected to enhance evapotranspiration and to significantly reduce the potential for water to percolate into the disposal unit, which will reduce contaminant mass fluxes that may reach an underlying groundwater system. An alternative cover system may be constructed as a monolithic water storage layer or a multi-layered capillary-barrier water-storage system (i.e., a layer of coarse-grained soil, the capillary barrier or break, overlain by a fine-grained soil that acts as the water storage layer). For the purpose of this paper, an ET cover constructed with a capillary break will be referred to as a capillary-barrier ET cover.

The presence of a capillary barrier (e.g., coarse-grained gravel layer or geosynthetic drainage layer) will further impede the vertical migration of water by causing water to be retained in the finer-grained soil layer (e.g., Khire et al., 2000). The contrast in unsaturated hydraulic properties at the capillary interface (i.e., between the two material layers) will form a hydraulic impedance that limits the downward movement of water. Hydraulic impedance results when a fine-grained soil overlies a relatively coarse grained

soil. The performance of a capillary break can be explained by the difference in the two materials unsaturated hydraulic properties. The finer-grained layer of a capillary break cover has the same function as that in a monolithic soil layer, which is to provide storage of water until it is removed via evapotranspiration. The coarse-grained layer forms a capillary break at the interface of the two layers, effectively holding back the water in the fine-grained soil via capillary forces (air entry pressure) until the soil near the interface approaches saturation. This phenomenon results in the finer-grained layer being able to retain more water than in a monolithic layer. As compared to an ET cover without a capillary barrier, the hydraulic impedance provided by the capillary barrier increases the storage capacity and retention time of the soil cover layer, thereby increasing evapotranspirative fluxes and reducing the flux of water into the gravel and underlying waste material.

Two alternative cover designs are reviewed in this paper and include a monolithic ET cover and a capillary barrier ET cover. Advantages of an alternative cover design include reduced complexity and as a result, reduced construction costs, ability to install monitoring equipment post-construction, the potential for significantly improved performance and increased longevity. Alternative cover systems are designed to meet or exceed the infiltration reduction performance predicted for conventional cover systems.

2.3 CASE STUDIES OF ALTERNATIVE COVERS

Numerous studies of ET covers have illustrated the effectiveness cyclical precipitation / evaporation aided by transpiration by a vegetated cover at reducing deep drainage through engineered cover systems, particularly in arid and semiarid regions (U.S. EPA, 2003; Albright et al., 2004; Scanlon et al., 2005; Fayer and Gee, 2006). As of August 2008, a U.S. EPA online database of alternative landfill covers revealed 40 demonstration and 36 full-scale projects throughout the United States (U.S. EPA, 2009). Table 2-1 presents some of the representative sites that are within or nearby Southeast Idaho. The table includes : the location, the average annual precipitation, the cap design, the regulatory program the cap was installed under, the wastes that were capped, and when the cap was installed and if it is a full-scale cap or a demonstration cap for each of the landfills/sites that are capped using an ET Cover.

Case studies illustrating the results of numerical simulations and/or field-based measurements at instrumented test facilities are presented for two alternative cover designs: a monolithic ET cover and a capillary barrier ET cover. The case studies discussed below summarize data regarding case study objectives, climate, cover design, and results. The focus of this paper is to demonstrate the proof-of-concept for alternative cover designs, rather than provide an exhaustive literature review.

The ratio between average annual precipitation (P) and potential evapotranspiration (PET) is used to define climate regimes and compare climatic conditions between sites. A P/PET ratio between 0.2 and 0.5 is indicative of a semiarid climate, while a ratio between 0.05 and 0.2 is indicative of an arid climate (UNESCO, 1979). For the purpose

of this paper, the terms percolation, drainage, infiltration rate, and water flux are used interchangeably.

2.3.1 MONOLITHIC ET COVERS

As discussed earlier, a monolithic ET Cover has no capillary break layer, but only a monolithic storage layer overlying the waste materials.

2.3.1.1 Operating Industries, Inc. (OII) Superfund Landfill

Objectives. The former Operating Industries, Inc. (OII) Landfill located outside of Los Angeles, California, was the first site to receive regulatory approval by the EPA for the construction of an ET cover system at a Superfund site. Information regarding the OII Landfill was taken from Zornberg et al. (2003), and summarized below. The site received both commercial and residential waste as well as hazardous waste. Chemicals of concern include both organic and inorganic compounds. The contaminated media include soil, groundwater, and air. Numerical modeling of water flow through an ET cover and a conventional cover containing a low-permeability layer was completed to compare the amount of percolation (water flux) through the cover between the two designs. Results from the numerical model were used to evaluate the equivalence requirement. Construction of the monolithic ET cover was completed in April 2000 after meeting all regulatory requirements.

Climate. Average annual precipitation for the site was estimated at 37.9 cm, while the average annual potential evapotranspiration was estimated at 101.5 cm. The climate dataset was synthetically generated with the HELP model but compared well to nearby meteorological stations. The P/PET ratio of 0.37 suggests a semiarid climate. Though not discussed by Zornberg et al. (2003), the majority of precipitation in this area (approximately 75%) is received during the winter (December through March) monsoons (WRCC, 2009a), a time characterized by low evapotranspirative fluxes. The average annual snowfall and snow depth was zero (WRCC, 2009a).

Cover Design. The monolithic ET cover consisted of a 150-cm layer of soil with an assumed saturated hydraulic conductivity of 10-5 cm/sec and unsaturated hydraulic properties typical of silty soils. In addition, a 60-cm layer of foundation soil was constructed beneath the engineered ET cover (but not included in the numerical model). The rooting depth was assumed equal to 30 cm to represent native annual grasses, and the fraction of radiation that penetrated the canopy (i.e., intercepts bare soil) was assumed to equal 25%.

The conventional cover from top to bottom consisted of a 30-cm protection layer, a 30-cm layer of compacted clay, and a 60-cm foundation layer. The conventional cover design was based on a consent decree as California's mandated prescriptive cover design. The clay was assumed to have a saturated hydraulic conductivity of 10-6 cm/sec, while the protection and foundation layers were assumed to have a saturated hydraulic conductivity of 10-4 cm/sec. The unsaturated hydraulic properties were based on

representative material types. Evaporation was assumed to occur from the surface of the conventional cover, while transpiration was set to zero.

Results. The amount of percolation entering the waste material was compared between the two designs in order to assess the relative performance of the two covers simulated with the numerical model. Overall, the percolation rate estimated for the conventional cover exceeded the rate predicted for the ET cover during a 30-yr period. The model-predicted cumulative water flux for the ET cover during the 30-yr climate record was 0.57 mm/yr, while the model-predicted cumulative water flux for the conventional cover was 4.38 mm/yr. The model results suggest that even though a wetting front may advance into the ET cover during the winter rainy season, water within the profile would be stored and later consumed during the growing season. Results from a sensitivity analysis suggested that the model predictions for the ET cover were not significantly different when simulations used site-specific hydraulic properties for the water storage layer. Sensitivity analyses also indicated that a 30-cm water storage layer would be sufficient to meet the equivalence requirement. However, the thicker 120-cm water storage layer was selected, probably to account for an increased factor of safety. In summary, the model simulations were able to quantify the expected performance of the ET cover and demonstrate improved performance compared to the conventional cover design, meeting the necessary requirements to receive regulatory approval. Moisture conditions within the cover were monitored for a 3-year period to assess the post-construction performance of the cover (ITRC, 2003).

2.3.1.2 Sandia National Laboratory Drainage Lysimeter

Objectives. As part of the Alternative Landfill Cover Demonstration Project, a series of large-scale conventional and alternative cover systems were constructed at Sandia National Laboratory in Albuquerque, New Mexico, to evaluate the performance of different cover designs. These were designed as test plots and as such are not actually capping any waste. However, the designs are meant to evaluate the various cover designs at minimizing infiltration to a waste layer. The majority of data summarized for this paper was reproduced from Dwyer (2003). Additional details regarding the results from the ET cover are presented by Scanlon et al. (2005). Water balance components (precipitation, irrigation, runoff, change in soil storage, and drainage) were measured with on-site instrumentation from May 1997 through June 2002. ET was computed as a residual as part of the water balance. A micrometeorological station was installed to monitor daily weather conditions. Results from the monolithic ET cover are discussed, and compared to the results from the conventional Subtitle D cover installed with a low-permeability layer of compacted soil.

Climate. Between 1998 and 2002 the average annual precipitation for the site was 25.8 cm, while the average annual potential evapotranspiration was 146.3 cm (Scanlon et al., 2005). The P/PET ratio was 0.18, typical of an arid to semiarid climate. Precipitation measured during the test period slightly exceeded the 30-yr average (22.6 cm) reported for Albuquerque (Scanlon et al., 2005). The majority of precipitation (~60%) in this area occurs during the summer monsoons between June and October (Scanlon et al., 2005), a

period that is characterized by high evapotranspirative demand. The average annual snowfall was approximately 24 cm, while the average annual snow depth was zero (WRCC, 2009b).

Cover Design. The test plots were divided into two subplots with east and west slope aspects at a 5% grade, and were 13-m wide and 100-m long. The west subplots were irrigated between late January and early February 2002 to facilitate evaluation of stressed conditions; a total of 11 cm of water was applied (Scanlon et al., 2005), which corresponded to approximately 40% of the average annual precipitation measured during the testing program. The test plots were constructed as drainage or pan (zero pressure) lysimeters with a basal geomembrane overlain with a geocomposite drainage system. Water that infiltrated through the covers was routed to an underdrain collection system for measurement. For a monolithic ET cover system, there is a potential that the drainage lysimeter may overestimate storage and underestimate percolation since the lower boundary resembles a capillary break and drainage would not occur until the interface between the soil layer and geocomposite drain approached saturation (Scanlon et al., 2005). Unfortunately, this is an inherent limitation and emphasizes the need to monitor multiple parameters within the cover (e.g., soil water storage and matric potentials) and evaluate the sensitivity of boundary conditions (e.g., seepage face versus unit gradient) using numerical modeling. Though not specifically mentioned, leak testing of the lysimeter prior to the initiation of testing was assumed. Surface runoff and percolation were routed to an underdrain collection system capable of measuring flows with cumulative percent errors of <0.2% per event.

The monolithic ET cover consisted of a 90-cm layer of soil overlain by a 15-cm layer of topsoil. A thin veneer of gravel (2 to 4 cm), designed to enhance establishment of vegetation and minimize erosion, was placed on the surface after the cover was seeded. Hydraulic properties were measured during three different timeframes: pre-construction, post-construction, and post-testing. For the monolithic water storage layer, the saturated hydraulic conductivity measured in the field was approximately 4x10-5 cm/sec. Rooting depth was assumed to terminate at 75-cm depth, and the average percent bare area for the ET cover was 82%.

The Subtitle D cover consisted of a 45-cm layer of compacted soil overlain by an upper 15-cm layer of loosely placed topsoil. The compacted soil layer was installed to mimic a soil barrier layer (e.g., compacted clay). The in-situ saturated hydraulic conductivity of the soil barrier layer measured during construction was 7.9x10-7 cm/sec, nearly an order of magnitude greater than the design goal of 1x10-7 cm/sec. During excavation of the test facility, the saturated hydraulic conductivity of the low-permeability layer measured in the field increased nearly two orders of magnitude to 1.2x10-5 cm/sec. An increase in hydraulic conductivity for the soil barrier layer agreed with desiccation and cracking observed during construction. The average percent bare area for the Subtitle D cover was 89%.

Results. The amount of percolation leaving the cover profiles was compared between the two designs in order to assess the relative field performance of the ET and Subtitle D

covers. Percolation measured from May 1997 through June 2002 for the Subtitle D cover exceeded the rate measured for the ET cover. The ET cover had a cumulative percolation of 0.30 mm resulting in an average water flux rate of 0.05 mm/yr; while the cumulative percolation for the Subtitle D cover was 8.34 mm resulting in an average water flux rate of 1.39 mm/yr. For the ET cover, drainage during the first two years of the five-year monitoring period was attributed to wet initial conditions from construction water and summer precipitation events. The decrease in drainage throughout the test period was attributed to the establishment of vegetation and removal of stored water; drainage did not occur during the irrigation stress test, which suggests that the storage capacity of the ET cover was able to successfully store water during an exceptionally wet winter. For the Subtitle D cover, drainage occurred during the first three years and the final year of monitoring. The larger drainage rate measured for the Subtitle D cover, as compared to the ET cover, was attributed to decreased storage capacity and smaller evapotranspirative fluxes, in addition to increased hydraulic conductivity and the development of preferential flowpaths that resulted from desiccation and cracking of the low-permeability barrier layer. Drainage reported for the Subtitle D cover during the final year was attributed to a snowstorm event and water that was applied during the irrigation stress test.

Overall, numerical simulations of flow through the ET cover generally agreed with field-based measurements. The model-predicted cumulative percolation for initial soil conditions (parameter values obtained shortly after construction) and for final soil conditions (parameter values obtained during excavation shortly after the program ended) exceeded the measured value by a factor of 2 to 3. Numerical simulations of flow through the Subtitle D cover were sensitive to the assumed saturated hydraulic conductivity. For example, the model predictions using initial soil conditions under-predicted the amount of percolation by an order of magnitude, while predictions using the final soil conditions slightly over-predicted the amount of percolation by a factor of 2. Clearly, spatial and temporal variations in the saturated hydraulic conductivity of the low-permeability layer, which may result from natural variability or decreased performance due to desiccation and cracking, complicate numerical predictions. In summary, the field measurements and model simulations were able to quantify the expected performance of the ET cover and demonstrate improved performance over the conventional cover design.

2.3.2 CAPILLARY BARRIER ET COVERS

2.3.2.1 Hanford Drainage and Weighing Lysimeters

Objectives. The U.S. Department of Energy (DOE) has evaluated the field-based performance of alternative cover designs for waste isolation at the Hanford Site north of Richland, Washington. A variety of designs that consist of different cover materials (e.g., sandy soils or silt loams that may include a surficial gravel layer) have been constructed to assess the long-term water balance under natural and stressed conditions through the use of lysimeters. Scenarios that simulate deteriorated conditions in regard to cover thickness and vegetation removal have also been evaluated. The majority of information

summarized for this paper was reproduced from Fayer and Gee (2006). Field performance of lysimeter studies conducted prior to 1987 and comparisons to numerical predictions are summarized in Gee et al. (1994).

To support the assessment of alternative cover designs for the Hanford Site, the Field Lysimeter Test Facility (FLTF) was built in 1987 and was operated for 17 years from November 1987 through 2004. The FLTF contains 14 drainage (pan or zero pressure) lysimeters, 4 weighing lysimeters, and 6 small tube lysimeters. The FLTF has been designed to specifically evaluate whether the alternative covers meet the infiltration control requirement. Water balance components (precipitation, irrigation, change in soil storage, and drainage) were measured with on-site instrumentation. Estimates of runoff and ET have not been reported by the authors. A micrometeorological station was installed nearby to monitor daily weather conditions. Results from different drainage and weighing lysimeters constructed as capillary barrier ET covers are discussed.

Climate. The average annual precipitation for the Hanford area was 16.2 cm, while the average annual potential evapotranspiration was 160 cm (Gee et al., 1994). The P/PET ratio was 0.10, typical of an arid climate. A significant proportion (73%) of the precipitation occurs between October and March, a period characterized by moisture accumulation while vegetation is dormant (Gee et al., 1994). The average annual snowfall was approximately 33.5 cm, and accounts for 38% of annual winter (December to February) precipitation (Gee et al., 1994). Weather during the FLTF monitoring period was slightly warmer and wetter with an average annual precipitation of 18.1 cm (Fayer and Gee, 2006).

Cover Design. A variety of designs exposed to different environmental conditions, all more or less based on a capillary barrier ET cover, were assessed as part of the FLTF. Fayer and Gee (2006) summarized a subset of the results from drainage and weighing lysimeters that consisted of four different cover configurations. The drainage lysimeters were approximately 200 cm in diameter and 300 cm deep, while the weighing lysimeters were approximately 150 cm on a side and 170 cm deep. The weighing lysimeters were situated on-top of platform scales to measure variations in moisture. The lysimeters were leak tested prior to initiation of testing. Drainage from all lysimeters was measured biweekly with a reported resolution of << 0.01 mm.

The first design, referred to as the Hanford Barrier Design, consisted of 150 cm of silt loam atop 25 cm of sand and gravel filter layers which acted as a capillary break. The capillary barrier layers were located above a 15-cm layer of coarse-grained railroad ballast and approximately 100 cm of basalt riprap. For the drainage lysimeters, a drain was located at a downslope outlet installed beneath the basalt riprap. The weighing lysimeters were similar in design, but did not contain a gravel layer or the underlying railroad ballast and basalt riprap. Twelve lysimeters of the Hanford Barrier Design were constructed. The second design consisted of the Hanford Barrier Design, but with the upper 20 cm of silt loam amended with pea gravel to protect against possible erosion (2 lysimeters). The third design consisted of the Hanford Barrier Design with a reduced thickness (100 cm) to represent an eroded test condition (3 lysimeters). The fourth

design consisted of the Hanford Barrier Design, but with the upper 20 cm of silt loam was removed and replaced with dune sand (4 lysimeters). A subset of the lysimeters was irrigated to facilitate evaluation of stressed conditions; water was applied to simulate the occurrence of a 1000-year storm (7.3 cm) and 2x and 3x the average annual precipitation (16.0 cm). During irrigation, water application was determined by the historical monthly average, and constrained by site-specific weather conditions. Because the cover systems were constructed with a capillary barrier, the lysimeters should function properly as a drainage lysimeter and accurately estimate the amount of percolation that migrates through the cover. Vegetation removal programs were also assigned to a subset of the lysimeters to evaluate a non-vegetated condition that may occur due to fire or natural disturbance. The lysimeter surfaces were generally well covered with vegetation; however, lysimeters covered with dune sand exhibited variable coverage of shallow rooted plants, which was attributed to uneven nutrient distribution within the cover material.

Results. The amount of percolation leaving the covers was evaluated to assess the field performance of the cover systems installed as part of the FLTF. Differences in drainage rates were interpreted to yield insight into physical and ecologic processes that may be controlling infiltration through the lysimeters constructed as capillary barrier ET covers. The discussion summarized below separates the results into scenarios that had drainage less than and greater than the design specification.

Six of the 12 lysimeters that incorporated the Hanford Barrier Design with plants reported zero drainage, even during enhanced precipitation scenarios (2x and 3x average annual precipitation), well below the design specification of 0.5 mm/yr. The monitoring timeframe varied for each lysimeter and ranged between 4 and 17 years. Two out of three lysimeters that incorporated the Hanford Barrier Design with a non-vegetated cover for an ambient precipitation record reported zero drainage (monitored for 10 and 13.2 years), while the remaining lysimeter reported an average drainage of 0.2 mm/yr after 8.2 years. Two vegetated lysimeters that incorporated the Hanford Barrier Design with gravel admix also reported zero drainage after 4.3 and 7.8 years. An enhanced precipitation scenario was not simulated for the gravel-admix configurations. Two vegetated lysimeters that incorporated the eroded Hanford Barrier Design (100-cm silt loam water storage layer) for an ambient precipitation record also reported zero drainage after 8.2 and 14.8 years. Finally, one out of the two vegetated lysimeters that simulated the fourth design (eroded Hanford Barrier Design covered with dune sand) with ambient precipitation reported a drainage rate of 0.16 mm/yr after 7 years. The other lysimeter reported zero drainage.

Significant drainage was reported for Hanford Barrier Design lysimeters that were non-vegetated and received enhanced precipitation. For the three lysimeters, no significant drainage was reported while the precipitation was increased 2 fold for three consecutive years; however, the amount of drainage significantly increased three years after the precipitation was simulated to mimic a 3x increase in precipitation. The initiation of drainage within the lysimeters coincided with the melting of a large snowpack. Shortly thereafter, two of the three lysimeters were converted to simulate erosion and deposition

of dune sand (i.e., the fourth Hanford Barrier Design) while the remaining lysimeter was left unchanged; all three tests continued to simulate a 3x precipitation scenario. Prior to conversion, the two lysimeters reported an infiltration rate of 6.2 and 16.4 mm/yr (10 and 7.8 year duration); after conversion the two lysimeters continued to report increased drainage with an average rate of 68.8 and 138 mm/yr (7 year duration). The increase in drainage after the lysimeters were covered with dune sand regarded despite the occurrence of shallow rooted vegetation. After the initial increase in drainage that followed the 3x precipitation increase, the unaltered, non-vegetated lysimeter reported little drainage; however, the initial drainage resulted in an average percolation rate of 10.7 mm/yr after 12 years. Clearly, the presence of surficial dune sand coupled with enhanced precipitation led to conditions that resulted in excessive drainage. Finally, one lysimeter was constructed to simulate the eroded Hanford Barrier Design with enhanced precipitation, and reported an average drainage rate of 2.4 mm/yr after 6.4 years.

In summary, the Hanford Barrier Design with and without plants for an ambient precipitation record reported zero drainage (except one lysimeter) and satisfied the design specification of limiting infiltration below 0.5 mm/yr. Of these simulations, the lysimeters that received enhanced precipitation and incorporated vegetation removal plans reported significant amounts of drainage; despite this, water did not drain from the lysimeter until the amount of annual precipitation was increased 3x. However, maintaining a non-vegetated cover was exceptionally challenging since on several occasions a one or two month hiatus in weeding resulted in extensive crop cover. Consequently, the authors concluded that plants would be expected to reestablish within a few months following a disturbance, and drainage should remain below the design goal. The FLTF study also indicated that the Hanford Barrier covered with gravel admix did not exceed the drainage design goal for an ambient precipitation scenario. If, however, the following conditions developed—erosion of the cover, deposition of dune sand, establishment of shallow rooted vegetation, and enhanced precipitation—drainage through the cover could be expected to exceed the design goal by a factor of 135 to 275.

Overall, measurements of drainage at the FLTF indicate that the Hanford Barrier Design (capillary barrier ET cover) will satisfy the infiltration requirement given current climate and vegetation conditions, regardless of whether erosion removes the upper 50 cm of the water storage layer. Results from non-vegetated lysimeters demonstrated that evaporation alone could limit percolation to well below the design standard assuming an ambient precipitation record. Additionally, numerical model simulations of the eroded Hanford Barrier Design assuming a scaled climate record based on paleoclimate reconstructions did not exceed the drainage design goal.

2.3.2.2 Monticello Uranium Mill Tailings Drainage Lysimeter

Objectives. As part of the Alternative Cover Assessment Program (ACAP), the U.S. DOE Office of Legacy Management and EPA Region 8 collaborated on the design and construction of a disposal cell to cap uranium mill tailings at a legacy site outside of Monticello, Utah. The Monticello Mill Tailings Site was placed on the NPL (Superfund) in 1989 because of concern regarding the high-concentration of radionuclides and trace elements in the tailings that may pose a risk to human health and the environment. The disposal cell design was subject to performance-based standards specified for Subtitle C facilities and design-based standards aimed at minimizing radon attenuation and maximizing longevity specified under Uranium Mill Tailing Radiation Control Action (UMTRCA). The U.S. EPA performance goal for the site was to maintain a drainage rate of less than 3 mm/yr or approximately 1x10-8 cm/sec. The majority of data summarized for this paper was reproduced from Waugh et al. (2008). Additional details regarding cover performance, and comparison with other ACAP sites located throughout the United States, are presented in Albright et al. (2004).

A series of field-based lysimeter experiments conducted between 1990 and 1999 were completed to evaluate different alternative cover designs and decide on a final cover configuration. The adopted cover design essentially consisted of a capillary barrier ET cover overlying a composite cover (geomembrane overlying an infiltration control layer). The composite barrier of the conventional design was accepted by the U.S. EPA to ensure that water flux through the cover would not exceed the rate of infiltration during the short-term. While the alternative cover configuration was installed to address uncertainty regarding the long-term durability of the geomembrane and low-permeability layer, and as a primary mechanism to limit long-term percolation. A large-scale drainage lysimeter was embedded within the cover during construction of the disposal cell during 2000 in order to assess the long-term performance of the alternative cover design. Two additional drainage lysimeters were constructed adjacent to the disposal cell to evaluate the range of as-built conditions in the actual alternative cover (Waugh et al., 2004). Water balance components (precipitation, runoff, change in soil storage, and drainage) were measured with on-site instrumentation from August 2000 through September 2007. ET was computed as a residual as part of the water balance. A micrometeorological station was installed to monitor daily weather conditions.

Climate. The average annual precipitation for Monticello was 38.5 cm, while the average annual potential evapotranspiration was 113.2 cm (Albright et al., 2004). The P/PET ratio was 0.34, typical of a semiarid climate. Precipitation measured between 2004 and 2006 exceeded the long-term average, and the total precipitation for a six-month period between September 2004 and February 2005 (53.1 cm) was greater than 250% of the long-term average. Calendar years 2001 through 2003 were characterized by below-average amounts of precipitation. The majority of precipitation (~60%) occurs during the spring growing season (April-June) and summer monsoons (July-October), periods that are characterized by high evapotranspirative demand. Approximately 40% of the precipitation occurs between November and March, a period characterized by moisture accumulation while vegetation is dormant. The site also receives appreciable amounts of

snowfall during the winter. The average annual snowfall was approximately 150 cm, while the average annual snow depth of 5 cm (WRCC, 2009c).

Cover Design. The cover of the disposal cell was 260 cm thick and constructed in two parts to create a combined alternative and conventional cover system. The lower part comprised the conventional cover design and consisted of a 60-cm soil layer compacted to serve as an infiltration barrier and radon attenuation layer. The compacted soil layer was overlain by a geomembrane. The upper part comprised the alternative cover design and consisted of a 170-cm water storage layer overlying a 30-cm capillary barrier. The 170-cm water storage layer from top to bottom consisted of 20 cm of soil-gravel admixture for erosion protection, 90 cm of fine-grained soil for soil water storage and frost protection, 30 cm of cobbles with a fine-grained soil matrix for protection against burrowing animals, 30 cm of sand for additional water storage and frost protection, and a geotextile filter to facilitate construction. The capillary barrier consisted of coarse sand.

A 7-acre drainage lysimeter was embedded within the cover during construction of the 40-acre disposal cell to assess performance of the ET cover. The lysimeter test plot was constructed as a drainage (pan or zero pressure) lysimeter, and created by welding a geomembrane flap to the existing geomembrane located at the base of the alternative cover design below the capillary break. The lysimeter was leak tested prior to initiation of testing (Albright et al., 2004). Surface runoff and percolation were routed to an underdrain collection system capable of measuring flows with a precision better than approximately 0.1 mm/yr (Benson et al., 2001). The upper portion of the cover is constructed as a capillary barrier ET cover. As a result, the lysimeter should function properly as a drainage lysimeter and accurately estimate the amount of percolation that migrates through the cover. The percent bare area, which excluded noxious and other weeds, decreased throughout the testing period and reached 46% during 2007.

Results. The amount of percolation leaving the capillary break of the ET cover was evaluated to assess the field performance of the cover system installed over the disposal cell independent of the lower composite barrier (i.e., geomembrane overlying the low-permeability layer). Overall, the drainage rate did not exceed the U.S. EPA performance goal of <3 mm/yr. The cumulative percolation measured from July 2000 through mid-October 2007 was 4.2 mm with an average water flux during the 7-yr monitoring period equal to 0.6 mm/yr.

Initially, the cumulative soil water storage within the lysimeter exhibited a decreasing trend in response to below-average precipitation and greater water extraction as plant roots developed. Drainage from the lysimeter was not recorded until the winter of 2004-2005. Approximately 80% of the percolation (3.4 mm) occurred during water year 2004-2005 (July 1 through June 30) in response to the above-average wintertime precipitation measured between September 2004 and February 2005. During this timeframe, drainage occurred because the amount of soil moisture in the lysimeter exceeded the storage capacity of the system. Afterward, water continued to drain from the lysimeter at a significantly reduced rate. For example, an additional 15% of the percolation (0.6 mm) occurred during the proceeding water year (2005-2006), likely in response to continued

infiltration of precipitation and increased moisture contents (i.e., elevated antecedent moisture conditions) within the cover. A wet summer monsoon season between July and October 2006 (almost twice the long-term average), coupled with wet antecedent moisture conditions, was likely responsible for drainage (0.2 mm) that occurred during 2006-2007. To date, a comparison between field measurements and numerical model predictions is warranted but has not been completed.

Percolation from the Monticello lysimeter is compared to another DOE legacy site constructed with a conventional low-permeability cover to yield insight into the relative performance between the two designs. The Lakeview Disposal Site in south-central Oregon is located in a similar climatic and ecologic setting as compared to Monticello. The water flux rate recorded for the Monticello capillary barrier ET cover was approximately 100 to 1000 times smaller than the percolation rate measured for the Lakeview site conventional cover.

In summary, the capillary barrier ET cover met the water-flux rate performance goal proposed by the U.S. EPA, despite the occurrence of an exceptionally wet winter during the monitoring period. Furthermore, the alternative cover design constructed at Monticello demonstrated improved performance as compared to a conventional low-permeability cover design constructed at another site in a similar climatic setting.

2.4 RCRA CAPS AT THE FMC POCATELLO PLANT SITE

As indicated in Section 1.0, there are several areas within the FMC Plant OU that are being considered for capping as a CERCLA remedial action. The experience that has been gained from the capped RCRA ponds at the site is valuable to consider in the evaluation of potential caps on the CERCLA areas being considered for capping. The purpose of this subsection is to provide a summary of that experience.

2.4.1 RCRA POND HISTORY AND BACKGROUND

While the FMC facility became subject to RCRA Subtitle C regulations for certain waste streams not subject to the Bevill Exemption (waste streams not unique to mining, beneficiation and specified mineral processing) in 1980, the waste streams directed to the ponds remained covered by the Bevill Exemption until March 1990. A total of twelve (12) surface impoundments that were “active” or constructed after March 1990 became subject to RCRA regulation, including permitting, closure and post-closure. Of these, eleven (11) ponds have been capped and one pond, Pond 18 Cell B, was closed by removal (“clean-closed”). These surface impoundments and associated operational information is provided in Table 2-2 and shown on Figure 2-2.

2.4.2 RCRA POND CAP DESIGN

There are some differences between RCRA cap designs among the eleven capped RCRA ponds. Ponds 8E, 9E and 17 do not have ET caps placed on top of the RCRA synthetic liner cap. Therefore, these caps are not relevant to the discussion here. The typical design for Ponds 8S, the Phase IV ponds (11S, 12S, 13Sand 14S), 15S, 16S, 18 Cell A is

described here and shown on Figure 2-3. The permanent RCRA cover system for these ponds consists of a seven-foot-thick ET water store and release system overlying a geosynthetic composite barrier and drainage system. This double cap design resulted from EPA concerns about the design life of the cap and the lack of data regarding the long-term integrity of geosynthetic barrier materials – high-density polyethylene (HDPE) geomembrane / geosynthetic clay composite liner (GCL) system - even though a 1997 chemical compatibility study (included with the Closure Plan) showed that the geosynthetic materials used for cap construction on Pond 16S were compatible with the chemicals in the sediments, including phosphine gas (PH3), under the cap (TRI/Environmental Inc., October 21, 1997).

The ET portion of the RCRA caps were designed based on a UNSAT-H model developed using very conservative soil and liner inputs as soil properties to be used in the cap were unknown at the time of design of the original RCRA cap (for Pond 8S). A summary of this modeling effort is presented in Appendix A of this report (taken from Appendix F of the *Pond 8S Closure Plan – May 1998*). This led to a very conservative design for the ET cap. Since the original RCRA ET cap design, the anticipated borrow soils, available on the western-most portion of the FMC Plant OU, have been tested as presented in Appendix B of this report (taken from Appendix D to the *Remedial Investigation Update Memorandum for the FMC Plant OU – June 2004*). A preliminary ET cap design, anticipated for application in the CERCLA Remediation Areas (RAs) of the FMC Plant OU is provided in Section 4.0 of this report and takes into account the actual borrow soil test data. It should be noted that the final ET cap design, if included in the selected remedial alternative, will be based upon similar modeling to be performed during the Remedial Design (RD).

2.4.3 RCRA Pond Cap Monitoring and Experience

All eleven capped RCRA ponds are currently being managed under EPA-approved Post-Closure Plans. Table 2-2 provides information of when the ponds were put into service, types of wastes received, when the pond was closed, when the caps were installed, and post-closure status. Post-closure monitoring will be continued for 30 years unless shortened or lengthened by the Regional Administrator in accordance with 40 C.F.R. §265.117. The post-closure monitoring is very similar between ponds, although some differences exist (e.g., Ponds 8E, 9E and 17 do not include monitoring of seepage rates through an ET cap drainage layer). It should be noted that the following activities are also required under the post-closure plans, but do not directly impact the ET cap performance and therefore are not discussed further in this report:

- A deed notice to restrict land use from any post-closure use which could jeopardize the integrity of the RCRA cap or interfere with ongoing monitoring and maintenance activities.

- Security systems to control access.

- Groundwater monitoring as required in FMC's *RCRA Interim Status Groundwater Monitoring Plans.*

- Pressure and Temperature monitoring to ensure the detection of reactions within the waste that could impair cap integrity.

Table 2-3 provides a summary of the general/typical observations of the RCRA cap monitoring/inspections at Pond 8S, which has the longest duration of on-going monitoring, e.g., approaching ten years of post-closure monitoring. Recent photographs of the RCRA ponds, taken in June 2009, are also included in Appendix C to provide a visual perspective of the RCRA caps.

2.4.4 Differences Between RCRA Ponds and CERCLA Remediation Areas (RAs)

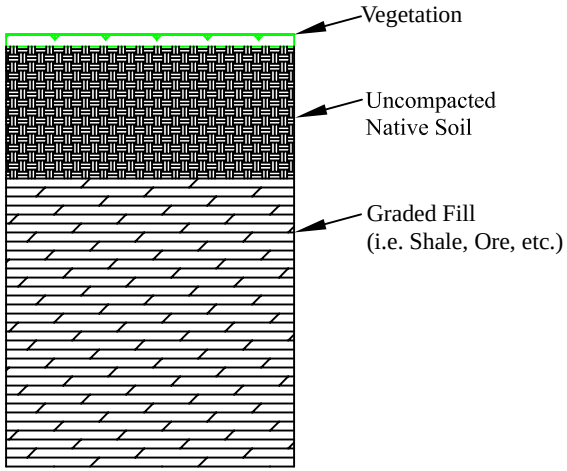
While the CERCLA RAs being considered for capping are described in detail in Section 3.0 of this report, it should be noted that there are some significant differences between the RCRA ponds at the time they were taken out of service and capped versus the CERCLA RAs. These differences, as listed here, will have a significant difference on the applicability, design, and effectiveness of an applied ET cap:

- The RCRA ponds were "active" at the time they were closed and capped. This required that the ponds were first "dewatered" by removing free water on the surface of the sediments. However, the sediments retained approximately 40% water when the first cap layers were applied. By contrast, the CERCLA RAs being considered for capping were taken out of service, "dewatered", and covered with 5 to 10 feet of plant fill materials (consisting of primarily slag, ore materials, concrete, and/or dried precipitator dust) from 1956 through 1981 (with exception of Pond 10S which was taken out of service in 1989 and remains uncovered). Although the final grading plan (to be developed during the Remedial Design) will determine the total depth of fill above the pond sediments within the RAs, it is assumed that the caps will be placed upon stable fill, as opposed to saturated pond sediments.

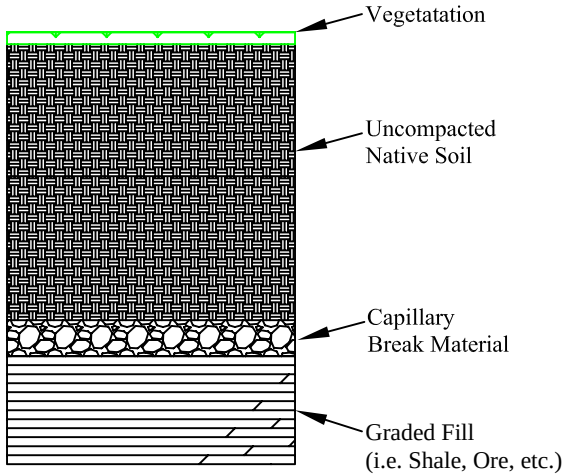
- The RCRA ponds, with exception of Pond 8S, are bottom-lined with single or double-layer synthetic liners. Therefore, once capped, the pond sediments are expected to retain water at levels similar to the time in which they were capped. By contrast, the CERCLA RAs are not lined allowing the sediments to dewater to levels similar to surrounding native soils.

FILE *Fig 3.1 FMC_Caps_409.ai 5/1/09*

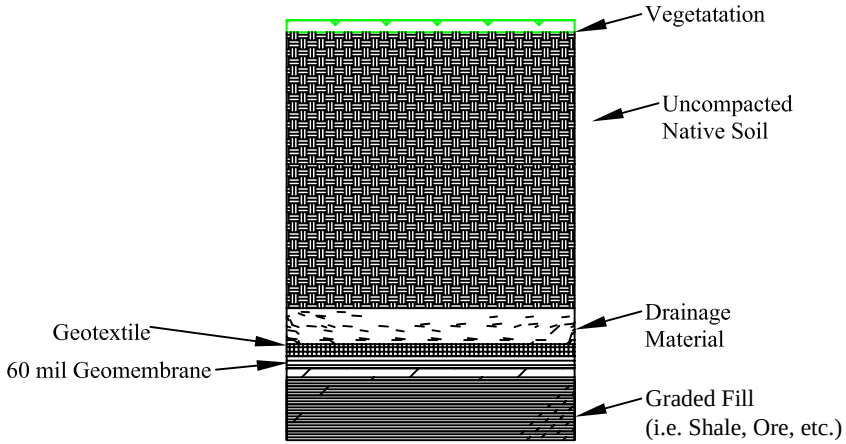
GAMMA CAP



ET CAP



MULTI-LAYERED CAP



MWH

FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2.1

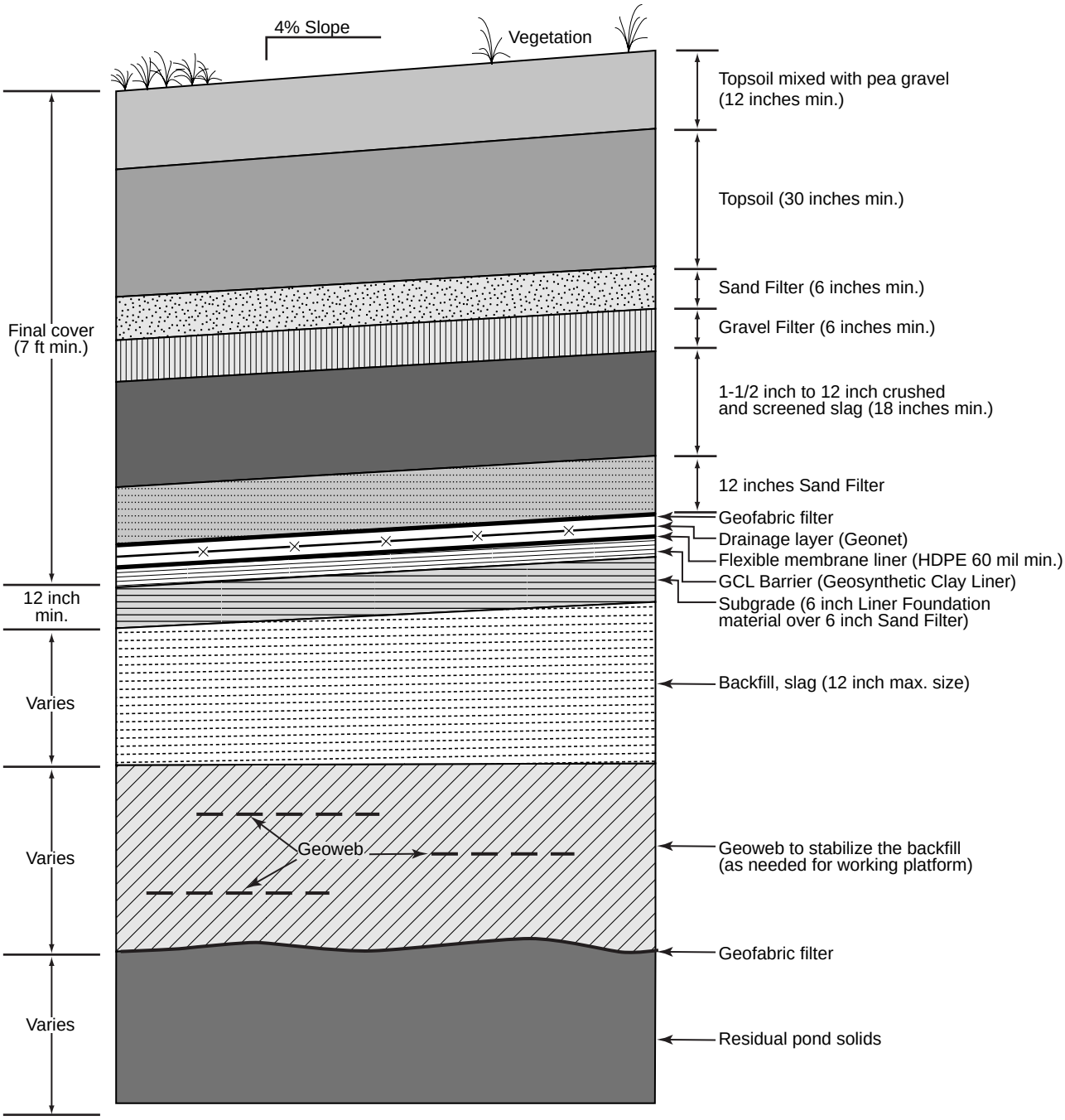
TYPICAL CAP DESIGNS

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2-2

RCRA POND LOCATIONS AT FMC

FILE Fig 2-02_RCRA Pond Locations at FMC_609.mxd 6/15/09



FILE Fig 2-03 FMC_Pond 8S Cap Design_609.ai 6/15/09

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FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 2-3

POND 8S CAP DESIGN

TABLE 2-1
OTHER NEARBY LANDFILLS USING ET CAPS

Landfill Name	Location	Average Annual Precipitation	Cap Design	Performed Under	Materials Capped	Date Installed
Fort Carson Landfill	Colorado Springs, CO	16 inches	Monolithic ET Cap - 48” of clay loam	RCRA Subtitle D	Municipal Solid Waste Landfill	Full Scale, 2000
US Ecology Subtitle C Landfill	Grandview, ID	7.3 inches	Unknown	RCRA Subtitle C	Typical hazardous wastes including organics (e.g., solvents, pesticides, and PCBs), metal, and radioactive wastes	Unknown, but approved in 2005 permit modification
Dugway Proving Ground	Dugway, UT	7.5 inches	Monolithic ET Cap – 15” of uncompacted native soils overlying a geosynthetic clay liner.	RCRA Subtitle C	Laboratory Wastes, Solvents, suspected Chemical Warfare Material, Office Trash	Full Scale, 2007
Rocky Mountain Arsenal Landfill	Denver, CO	15.6 inches	Various covers, 42 to 48”thick Monolithic ET caps of fine grained material (loam/clay loam) to coarse materials (sandy loam) in 4 caps designs overlying VFPE liner	RCRA Subtitle C	Hazardous Waste Site	Demonstration, 1998
Idaho National Laboratory CERCLA Disposal Facility	Idaho Falls, ID	8.7 inches	Various including: 1) Monolithic ET Cap: 2.0m of loess with no Capillary Break; 2) Capillary Break ET Cap 1.0m of loess, 0.1m of gravel, 0.2m of cobble 0.1m of gravel, and 1.0m of loess; 3) Capillary Break ET Cap 0.5m of loess, 0.1m of gravel, 0.2m of cobble, 0.1m of gravel, and 1.5m of loess	RCRA Subtitle C	Radioactive Wastes	Demonstration 1988 plots to present
Hanford Superfund Site	Richland, WA	160mm or 6.3 inches	Capillary Break ET Cap - 15cm of 1-3cm Gravel overlying 135cm of silty loam over a 3-layer gravel/sand filter (in addition, other designs were tested)	RCRA Subtitle C	Hazardous Waste Site	Full Scale 1994
Polson MSW Landfill	Polson, MT	15 inch	Capillary Break ET Cap - 6”topsoil, 18”mod compacted silt, 24” sandy gravel capillary break	RCRA Subtitle D	Municipal solid wastes	Full Scale 1999/2000
Bayview Landfill	Provo, UT	10.5 inches	Monolithic ET Cap - 36” of silty sand	RCRA Subtitle D	Municipal solid wastes	Full Scale 2005
Lewis and Clark County Landfill	Helena, MT	12 inches	Capillary Break ET Cap - 6”topsoil, 47”sandy clay, geo-textile, 12” gravel capillary break	RCRA Subtitle D	Municipal solid wastes	Demonstration 1999

Much of the information presented in this table can be found on the EPA’s Clu-in web site at the following path: http://www.cluin.org/products/altcovers/usersearch/lf_search.cfm

TABLE 2-2

DESCRIPTION OF RCRA-CLOSED PONDS[1]
FMC Corporation, Pocatello, Idaho

Pond #	Description of Wastes Received	Date Put Into Service	Pond Size (acres)	Date Last Received Waste	Year Final RCRA Cap was Installed	Post-Closure Status
8E	NOSAP slurry[2], phossy water and phossy solids	1984	4.1	1997	2004	Following PC Plan since Jan 2005
9E	Precipitator slurry	1986	12.9	1994	2000	Following PC Plan since Jan 2001
8S	Phossy water and phossy solids	1970	3.2	1981	1999	Following PC Plan since Dec 1999
11S	Phossy water and phossy solids	1980	1.9	1993	2004	Following PC Plan since Jan 2005
12S	Phossy water and phossy solids	1980	2.2	1993	2004	Following PC Plan since Jan 2005
13S	Phossy water and phossy solids	1980	2.2	1993	2004	Following PC Plan since Jan 2005
14S	Phossy water and phossy solids	1980	2.6	1993	2004	Following PC Plan since Jan 2005
15S	Phossy water and phossy solids	1982	9.4	1993	2004	Following PC Plan since Jan 2005
16S	NOSAP slurry[2], phossy water and phossy solids	1993	10.2	1999	2004	Following PC Plan since Jan 2005
17	NOSAP slurry[2]	1998	9	2001	2005	Following PC Plan since Dec 2005
18A	Phossy water and precipitator slurry	1998	3.8	2001	2005	Following PC Plan since Dec 2005
18B	Clarified overflow from Pond 18 Cell A	1998	12.4	2001	2005	Closure by removal (“clean closed”)

[1] Other Pre-RCRA, unlined ponds are grouped as RA-C and RA-D
[2] Non-hazardous slurry assurance project (NOSAP) slurry consisted of lime-treated precipitator slurry

Table 2-3
Pond 8S RCRA Pond Post-Closure Monitoring/Inspections and Required Actions Specific to Cap Performance

Post-closure Monitoring/Inspection Activity	Historical Observations[1]	Actions taken to date.
Quarterly inspections		
Cap and vegetative cover	1. Some minor erosion channels observed at edge of cap at outer edge of cap where slope increases. 2. Some small areas of inadequate vegetative cover, primarily at outer edge of cap where slope increases.	1. Erosion channels are filled in with soil upon detection after quarterly inspections. 2. Areas are re-seeded as needed. Some recurring areas have been addressed with erosion mats.
Monuments	No issues with settlement monuments observed.	None to date.
Drainage systems	No significant surface drainage issues observed other than minor erosion indicated above.	None to date, other than filling minor erosion channels.
LCDRS	No leachate accumulated from LCDRS.	None to date.
25-year, 24-hour storm event inspection	No 25-yr, 24-hr storm events to date.	None to date.
Cap drainage monitoring	No seepage measured through Pond 8S ET cap system.	None to date.
Topsoil monitoring	No detectable loss of topsoil from water or wind erosion other than as noted above for runoff erosion.	None to date.
Settlement monitoring		
After final cap	Horizontal and vertical settlement measurements have been within expected design limits.	None to date.
Visible subsidence or local seismic event	No visible subsidence has been observed. No seismic events recorded.	None to date.

[1] Pond 8S has been in place and under the RCRA Post-Closure Plan since 1999.

SECTION 3.0 COMPARATIVE CAP EVALUATION

This section provides an evaluation of both conventional and alternative covers as they relate to achievement and/or compliance with the remedial action objectives (RAOs) identified during development of the SFS in the CERCLA process. The RAOs are specific objectives necessary for the cleanup of the site that are determined by the COCs detected in site media during successive remedial investigations (RIs). Alternatives that are assembled for the site cleanup then must not only remediate the site based on the COCs present, but must comply with the federal, state, and local regulations/laws during the remediation. The purpose of this section is to evaluate whether an alternative cover can provide a similar level of protection to human health and the environment as a conventional (multi-layered) cover system while satisfying the necessary regulatory requirements. The reader must keep in mind that containment (i.e., capping systems) is just one of the technologies that are being evaluated for the FMC Plant OU remedial action.

3.1 REMEDIAL ACTION OBJECTIVES (RAOs)

The RAOs for the FMC Plant OU are presented in the SFS Work Plan (MWH, 2008) and in summary consist of the following:

- Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4.

- Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk hazard quotient (HQ) of 1.

- Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1.

- Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1.

- Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. Note this RAO only applies to areas with shallow P4 (i.e., RA B and underground piping containing P4).

- Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1. Note this RAO only applies to areas with P4 (i.e., RA B, RA-C, RA-F1, RA-K and underground piping containing P4).

- Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.

In addition to the RAOs, any caps constructed at the site would be designed to meet appropriate performance criteria and design considerations. Section 3.4 describes the performance criteria that would be expected to apply to any cap type installed within RAs containing wastes and fill materials that present risks from direct contact or infiltration to soil and groundwater similar to risks at the RCRA-regulated units.

3.2 REMEDIATION AREAS (RAs) CONSIDERED FOR CAPPING

The following site characteristics indicate that capping is likely to be an effective and appropriate remedial alternative at a substantial portion of the FMC Plant OU:

1) The COCs present in site soils and fill;

2) The types of wastes to be capped (soils/solids);

3) The volume of material to be capped (much like a mining site in that it is a mineral processing site consisting of hundreds of acres).

4) The fact that significant areas of the site have already been capped and capping has been demonstrated to be effective and implementable.

5) Excavating and handling P4 in widely varying concentrations in the subsurface would create significant risks to site workers from potential direct exposure (burns) and exposure to oxidation/reaction products.

6) Removing soils with P4 could create significant risks to the public due to potential P4 oxidation and resultant air emission products.

As discussed in Section 1.0, this paper only deals with those RAs that have known groundwater impacts or have the potential to impact groundwater and therefore, would require either a conventional or alternative cover system to reduce infiltration and potential release/migration of COCs to groundwater. RAs exhibiting only gamma radiation do not pose a threat to groundwater are assumed to be adequately addressed with a gamma cap. These areas therefore are not discussed in this section. The RAs discussed as part of this white paper are summarized in Table 3-1. For each RA, this table presents the following:

1) A description of the industrial operation that occurred in the RA and the primary fill/source materials it contains;

2) The solid waste management units (SWMUs) and remediation units (RUs) contained within the RA;

3) Exposure scenarios of concern that were used to identify the need for and types of potential remedial action (i.e., technologies/process options useful in mitigating the risk) for that RA; and

4) The RAOs that must be addressed.

Figure 3-1 depicts the boundaries of each RA. The RAs that would be considered for remediation using conventional or alternative caps are shaded in this figure.

3.3 COMMON ELEMENTS TO CAPPING REMEDIAL ACTIONS

There are several common elements that would be incorporated into any alternative that includes capping. These actions, listed below, would be performed in conjunction with cap construction:

- Cap Integration and Stormwater Management – Proper management of stormwater is necessary to prevent erosion of caps and prevent ponding of water over impacted areas. Stormwater would be addressed by cap integration and site grading to promote runoff and collection of stormwater from capped areas in a way that minimizes degradation of the caps and maintains a zero discharge of stormwater from the site to surface waters. A stormwater retention basin(s) would likely be needed for stormwater management.

- Soil Management – A soil management plan would be required as part of the deed restrictions to ensure that disturbance, management, and/or disposition of site fill/soil is controlled to prevent future site receptor exposures. Soil management would be implemented through prohibition of excavation in certain areas (multi-layer or ET caps) or requirements for managing excavated soil (gamma caps) during future land use changes (i.e., site development).

- Institutional Controls – Institutional controls including fencing, deed restrictions, and access controls would be implemented across the entire site. Deed restrictions would include the following:

    - Prohibition on construction/excavation in areas known to contain P4 or containing multi-layered caps;

    - Access restrictions including the current facility fencing, gates, and warning placards to prevent unauthorized site access;

    - Requirement for soil/fill management planning; and

    - Limiting future site use to commercial/industrial development only.

- Fugitive Dust – Fugitive dust would be addressed by establishment of vegetation on disturbed/remediated areas, routine watering of unpaved roads and other best management practices.

Monitoring. The following performance monitoring activities would be incorporated as part of any remedy that includes capping:

- Phosphine (PH3) Monitoring – Monitoring for phosphine gas would be performed at multi-layer or ET cap areas known to contain P4, including at RA-B, RA-C, RA-K (railroad swale), and RA-F1 (railcars buried in the slag pile). This monitoring would be performed to the extent and duration necessary to assure protection of human health and the environment with respect to gases that may present on or around the capped area at levels that present a concern to human health or the environment.

- Confirmation Sampling – Confirmation sampling would be performed during the remedial actions to ensure the proper delineation of the capped areas (i.e., confirm areal extent of cap).

- Groundwater Monitoring – Monitoring of site groundwater would be performed to evaluate the performance of the remedial actions from several former potential source areas of the site including the site landfills (RA-H and RA-F2) and RA-B. Groundwater monitoring of these former source areas will be coordinated with the monitoring that may be necessary in connection with the selected FMC Plant OU groundwater remedy.

3.4 PERFORMANCE CRITERIA FOR CONVENTIONAL AND ALTERNATIVE COVERS

Based on the established RAOs, the following four performance criteria were developed for evaluating conventional (i.e., multi-layered) and alternative cover systems for RAs to be capped at the FMC Plant OU:

- Preventing direct P4 exposure
- Reducing infiltration
- Fate and transport of gases
- Long-term durability.

A discussion of each of the performance criteria along with a comparative evaluation of the two capping systems is provided below. However, it is important to first recognize the physical and chemical differences between RAs when evaluating the application of a conventional versus alternative cover system against these performance criteria. These differences are summarized below:

Fate and Transport of Gases

- Of all the CERCLA areas being considered for capping, RA-C (the historic ponds containing P4) has the highest potential for phosphine generation. RA-C has a significant estimated quantity of P4 (4,440 to 10,800 tons), P4 at relatively high concentrations, and both pond sediments (including precipitator solids) and P4. However, as described in Section 2.4.4, the historic ponds within RA-C were dewatered and covered 28 to 53 years ago and do not have an under-liner. Therefore, the potential for phosphine generation is far lower than at the RCRA ponds, most notably Pond 16S.

- Although RA-B (furnace building, slag pit, phos dock and secondary condenser) has an estimated 580 to 5,470 tons of P4, the P4 was deposited as P4 product migrating through the subsurface soils. There are no pond sediments present. Therefore, the potential for phosphine generation is estimated to be significantly lower than RA-C.

- RA-D consists of historic ponds with only residual quantities of pond sediments and no P4 and therefore presents a very low potential for phosphine generation.

- RA-E (calciner area) does not contain any P4 (except for potentially small amounts in the old underground CO line identified in RU8) and therefore does not present a potential for phosphine generation.

- RA-K (railroad swale) has been investigated and is estimated to contain relatively low volumes of P4 (4 to 10 tons) at low concentrations. Therefore, RA-K is presumed to have a very low potential for phosphine generation.

- RA-F1 (buried railcars) has an estimated 200 to 2,000 tons of P4, but as in RA-B, the P4 in the railcars would not be associated with pond sediments. In addition, the railcars are buried at a significant depth (80 to 100 feet) in the slag pile. Therefore, the potential for phosphine generation is estimated to be significantly lower than RA-C or RA-B.

- Although underground piping may contain precipitator slurry and/or phossy solids (i.e.,, pond sediment material) and P4, underground piping is not considered to present a significant potential for phosphine generation as the mass of materials within the piping is distributed over a very long length of pipe run but relatively small area around the pipe, i.e., very low mass of P4 in a given area.

Direct P4 Exposure

- RA-B is considered to have the greatest potential for direct P4 exposure compared to other areas due to the volume, concentration, and relatively shallow depth at which P4 may be encountered.

- RA-C has a lower potential for direct P4 exposure than RA-B as the P4 in historic ponds is estimated to be covered with over 10 feet of fill material.

- RA-D (historic ponds without P4) and RA-E (calciner area) do not contain P4 (except for small amounts associated with underground piping) and therefore do not present a potential for direct P4 exposure.

- RA-K (railroad swale) has relatively low volumes of P4 at low concentrations and at shallow depths (less than 10 feet). Therefore, RA-K is presumed to have a moderate potential for direct P4 exposure.

- As the P4 in RA-F1 (buried railcars) is buried at significant depth (>80 feet), RA-F1 is considered to have a very low potential for direct P4 exposure.

- Underground piping may contains P4 at relatively shallow depths (typically less than 5 feet) distributed over a long length of pipe run but relatively small area around the pipe. Therefore, the underground piping has a relatively high potential for direct P4 exposure.

3.4.1 DIRECT P4 EXPOSURE

Evaluating cap performance related to direct exposure involves assessing conventional and alternative covers' ability to achieve RAOs established for soils and solids. The main aspect of this performance criterion is the ability of caps to prevent direct contact by human and ecological receptors with COCs in site soils. For RAs B and C which contain elemental phosphorus, preventing direct exposure also includes isolating the P4-containing media from oxygen sufficiently to prevent spontaneous combustion.

Both conventional and alternative caps can successfully prevent direct exposure of human and ecological receptors to COCs in site soils. Protection of human health and the environmental can be assured through a combination of sufficient cap thickness and institutional controls, as discussed in Section 3.3 above, to prevent cap intrusion. For ecological receptors, direct contact to soil COCs is achieved by the incorporation of a bio-barrier into the cap design. Both conventional and alternative covers are commonly designed with a bio-barrier to prevent intrusion of ecological receptors into the underlying waste. Bio-barriers typically consist of gravels or cobles and can also be designed to serve as a capillary break.

The major concern at RAs where elemental phosphorus may be present is the potential for P4 to spontaneously combust when exposed to air. RAs B and C and underground piping have the greatest potential for encountering elemental phosphorus at levels that would spontaneous combust. However, under present conditions, the elemental phosphorus is sufficiently isolated to prevent such combustion. The addition of either a conventional or alternative cover would provide an additional level of protection.

3.4.2 LIMIT INFILTRATION

One of the primary purposes of any capping system is to limit the infiltration of precipitation into and through underlying waste. As discussed in Section 2.0, conventional and alternative covers achieve this reduction in different ways. Conventional covers use one or more hydraulic barrier layers, consisting of low permeability clay or geosynthetics, to provide a barrier to infiltration. An alternative cover, in contrast, prevents precipitation from infiltrating into the underlying wastes using the principle of store-and-release. This is achieved by placing a soil storage layer and planting and maintaining native vegetation to store and evapotranspirate precipitation.

As discussed in Section 2.0, the performance of alternative covers at limiting infiltration has been evaluated at many sites throughout the semi-arid and arid west. The case studies at those sites indicate that alternative covers have reduced infiltration rates well below the performance criteria established for the sites. The climate at Pocatello, Idaho where the FMC Plant OU is located is characterized as semi-arid, with a precipitation to potential evapotranspiration (P/PET) ratio of 0.39. The low P/PET ratio indicates that the site is a good candidate of sustaining a functioning alternative cover that, if properly designed, could essentially eliminate infiltration.

The caps constructed at the closed RCRA ponds include both a conventional cover, consisting of both a compacted clay and geomembrane liner, and an overlying ET cover. This redundant cap design was designed to address EPA's concern regarding the longevity of the geomembrane liner. The Pond 8S RCRA cap has been in place for the past nine years and has not had a detection of any infiltration through the capillary barrier that underlies the 42-inch storage layer.

The ET portion of the Pond 8S RCRA cap was designed based on a UNSAT-H model developed using very conservative soil and liner inputs. Since the time of the original design, the anticipated borrow are soils have been tested (refer to Appendix B). A preliminary design of the proposed ET cap, preformed using material testing results from the anticipated borrow area, is provided in Section 4.0. These data were not available at the time the original ET cover was modeled and designed and thus, the monolithic cover on all the RCRA ponds is likely the maximum design thickness that would be required for the site conditions.

In addition to soil layering, establishment of vegetation is necessary for a successfully functioning cap. Although it can be difficult to establishment vegetation in arid and

semi-arid regions, FMC has successfully done this on the current RCRA caps. Photographs showing the vegetative cover on the RCRA ponds are presented in Appendix C. The seed mix used on all of the RCRA ponds is shown in Table 3-2. If necessary, the proposed ET caps could be irrigated for one or more growing seasons to ensure establishment of vegetation.

Although geomembranes in principle achieve low predicted overall hydraulic conductivity, the actual performance of liner systems to limit infiltration depends greatly on the quality of their installation. Liner performance is determined through a method originally developed by Giroud and Bonaparte (1989) and is based on good liner installation and maintenance. From the preliminary surveys done by Giraud and Bonaparte and later work by the U.S. EPA (1992), it was found that a geomembrane liner system installed with good construction quality assurance will have about 1 hole of 2 mm diameter per acre. Furthermore, Nosko et al. (1996, 2000) and Rollin (1999) have shown that for covered liners most damage (greater than 70%) is caused during placement of the cover soil. Because lined caps rely on the low hydraulic conductivity of the liner material, any tears, punctures or faulty seams created during construction can have a significant effect on the liner's ability to limit infiltration.

3.4.3 Design Consideration for Fate And Transport Of Gasses

One of the design considerations for the proposed caps is the generation of phosphine gas from areas containing P4. This design consideration only pertains to RA-B, RA-C, the RA-K (the railroad swale), and RA-F1 (the railcars buried in the slag pile). The primary processes for chemical transformation of P4 are oxidation and hydrolysis. In a solid phase such as in soil, P4 reacts with available oxygen to form phosphorus pentoxide (P4O10, commonly expressed as P2O5), which exists as a particulate at ambient conditions. Phosphorus pentoxide has a strong affinity for water and will react with available water (hydrolyze), including moisture from the atmosphere, to form various phosphorus acids, primarily orthophosphoric acid (H3PO4). In soils, due to limited availability of both oxygen and water, these reactions proceed slowly and incompletely, occurring on the outer edges of the solid P4 that forms a crust that can further slow the reaction by reducing the surface area available to contact oxygen and water. In water, dissolved P4 is oxidized by dissolved oxygen (DO) to form various forms of soluble phosphorus acids, including H2PO4^{-}, HPO4^{-}2, and PO4^{-}3. In water with other dissolved ions, and depending on environmental conditions such as pH and Eh, these acids may be further converted to a solid metal phosphate compound such as calcium phosphate. The rate of phosphorus oxidation in water is governed by the form of the phosphorus (dissolved or suspended), DO concentration, salt concentration, metal ion concentration, pH, and temperature.

P4 also is hydrolyzed in water to form phosphine and lesser amounts of phosphorus acids. Phosphine is a toxic gas that has a low solubility, and thus is expected to migrate from the water to the air; the portion of phosphine that dissolves is generally oxidized to form the above-referenced forms of phosphorus acids. The rate of hydrolysis of P4 is enhanced by an increase in the pH of the water reacting with the white phosphorus (WP).

(USACE, 1998). In the presence of soil moisture, the P4 contained in soils may react to form phosphine gas, depending on a number of variables including temperature, pH, presence of metal phosphides (present in precipitator solids), and the amount of water present. As phosphine is heavier than air, phosphine gas would be expected to travel horizontally in soils, unless a preferential pathway would allow for upward migration through the soil column. As it travels through the soil, phosphine would be likely reacting with both air in the pore spaces of the soil or soil constituents to convert to P2O5, phosphoric acid, and/or phosphate compounds.

As part of ongoing industrial hygiene monitoring at the site, phosphine monitoring is routinely conducted in the RCRA pond area and periodically conducted at other locations. With the exception of certain instances infrequently observed at isolated locations on Pond 16S, industrial hygiene monitoring at or above the ground surface has not indicated detectable levels of phosphine. This is significant in that RAs containing P4, e.g., RA-B and RA-C, are currently largely covered with soils or slag, essentially providing a permeable cover through which any gas generation would be migrating, and reacting, forming solid phosphates prior to reaching ground surface.

Pond 16S is a unique among the capped RCRA ponds and is significantly different from the areas with P4 being addressed as part of the CERCLA SFS. Pond 16S was designed and built with a bottom liner system consisting of two 30-mil-thick PVC geosynthetic barriers with a leachate collection, detection, and removal system (LCDRS) between the liners. The 10.2-acre pond was filled with process wastes to a maximum depth of 25 feet, comprising a total of 140 acre-feet of phossy water and pond sediments. Placement of initial fill and a temporary cover was completed in October 2000. After a 3-year period of consolidation of the waste materials and cap materials in the pond, the permanent (final) cap was installed over Pond 16S in the fourth quarter of 2004.

The permanent cover system consists of a seven-foot-thick evapotranspiration (ET) water storage and release system overlying a geosynthetic composite barrier and drainage system. Underlying the geosynthetic composite barrier is a layer of sand and a layer of backfill (consisting of slag) for a total underlying depth varying from 5 feet (at the perimeter) to 15 feet (at the center crown). It is well documented that phosphine gas emissions were evident from Pond 16S prior to capping and during the consolidation period of the temporary cover. While the generation rate was believed to have been greatly reduced prior to installation of the final cap, gas emanation from the pond sediments likely continued after installation of the final cap. The steel TMP casings are sealed to the cap geosynthetic composite barrier via a boot. An unsealed ¾-inch pipe, however, runs from the surface of the cap to the bottom of the TMP casing to provide a conduit for removal of the temperature probe. This conduit piping was not sealed and has provided a direct path for gases from the sediments to the surface. Following this path of least resistance, releases of phosphine gas and other gases present under the cap's geosynthetic composite barrier have been observed from the TMPs. A gas extraction system has been installed and operated since November 2007 to treat the phosphine gas accumulated under the Pond 16S cap and reduce phosphine levels to a pre-determined level.

The high levels of phosphine gas at Pond 16S can be attributed to the fact that both phossy solids and precipitator solids were discharged into the ponds. This combination in the presence of water contained in the pond sediments promotes the generation of phosphine. This condition does not exist in either RA-B, RA-C, RA-K or RA-F1. Therefore, it can be assumed that significantly lower phosphine gas generation would be would be present in the soil overlying these areas as compared to the process waste directed to Pond 16S. Industrial hygiene monitoring supports this assumption.

As demonstrated at Pond 16S, capping an area with precipitator/phossy solids and elemental phosphorous using low permeability geosythetics can result in accumulation of phosphine gas under the cap. As the capped area is "sealed" from the ambient air, the oxygen within the RCRA caps becomes depleted following the cap placement and therefore is not available to allow the natural conversion of the phosphine gas to P2O5 and eventually to phosphoric acid. The use of an alternative cover (ET cap) would allow for diffusion of air and moisture within the soil column, allowing for a continuous source of oxygen to react with any upward migrating phosphine gas. This would, convert the phosphine to phosphoric acid and other phosphate compounds before it reached the surface in detectable quantities.

The rate of phosphine gas diffusion through soil is not well understood, although is likely dependent on barometric pressure fluctuations. Studies performed on radon gas diffusion can provide a useful analogy for assessing the adequacy of soil covers to attenuate phosphine gas. From research performed by Macbeth et. al. (1980), attenuation of radon gas is a function of cover thickness, moisture content, and soil type. In general, their research demonstrated that sufficient radon attenuation was possible using native cover soils and may result in greater long-term protection than geosythetics liners. One difference between radon and phosphine is their degradation pathways. Radon is attenuated via advective dispersion and radiological decay, whereas phosphine is predominantly attenuated via oxidative reactions. A study conducted by the Agency for Toxic Substances and Disease Registry (ATSDR) concluded that, in soils to a depth where oxygen diffusion occurs, elemental phosphorus primarily attenuates through oxidation. (http://www.atsdr.cdc.gov/toxprofiles/tp103.html#). The oxidation of phosphorus to its oxides is usually rapid. Elemental phosphorus is oxidized within 2 days in soil at ambient temperatures (Rodriguez et al., 1972). Therefore, the extent of attenuation of phosphine would be controlled to a large degree by the amount of oxygen and/or soil moisture in the cover soil.

Hydrolysis of elemental phosphorus in the atmosphere can produce phosphine. The production of phosphine is inversely related to oxygen concentration, and is thus favored by low oxygen pressures (Spanggord et al., 1985). Therefore, constructing a cover that would "breath" would allow for a continuous source of air that would favor the degradation of phosphine to phosphoric acid. When phosphine is formed, it decomposes to several lesser known intermediates such as P2H4 and finally to H2PO4 (phosphoric acid), salts, and water. In the presence of oxygen, these breakdown products are formed rapidly from phosphine (Garry et al. 1989). This could possibly explain why significant concentrations of phosphine have not been routinely detected at the surface of Pond 16S

(except at or around the TMP wells that provide a direct pathway from the sediment layer through the engineered cover to the cap surface) and why phosphine accumulates to the high levels beneath the synthetic cap liner.

While phosphine would be expected to react with oxygen in the cap soil to form P2O5 which would further react with moisture in the soil to form H3PO4, the H3PO4 would also be expected to react with the alkaline soils to form phosphate compounds. These phosphate compounds, if at or above detectable levels, would be beneficial to vegetation growing on the cap. At the very low levels of phosphine expected within the cap soils at the FMC Plant OU, phosphate compounds would not be expected to build to levels that would change cap chemistry or physical properties, i.e., hydraulic conductivity.

3.4.4. LONG-TERM DURABILITY

Evaluating the long-term durability of conventional and alternative covers is necessary to determine their effectiveness at achieving long-term risk reduction, especially reduction in infiltration. The main factor that affects the long-term performance of conventional covers is the integrity of the barrier layers. Because conventional covers rely on the presence of one or more barrier layer to prevent downward migration of precipitation, any reduction in the long-term integrity of either compacted clay or geomembrane liners can significantly affect the ability of the cover to perform its primary function of reducing infiltration. The majority of conventional covers constructed with a flexible membrane liner (FML) use HDPE for both its high strength properties and chemical resistance. Although not common, HDPE liner failures have been documented. HDPE liners fail or are made to fail by the following:

- Inadequate welding and attachment to structures;
- Imposed stress during construction;
- Mechanical damage during construction;
- Stress cracking at stress points;
- Service stresses that separate welds;
- Ultraviolet light oxidation; and
- Chemical attack.

Apart from poor welding and damage induced during installation, HDPE geomembranes have only failed by stress cracking or oxidation induced stress cracking (Peggs, 2003). Nosko et al. (1996, 2000) and Rollin (1999) have shown that in covered liners most damage (greater than 70%) is caused during placement of the cover soil and only 24% were a result of seam failure. Although there are substantial laboratory data demonstrating that the degradation of HDPE liners is a slow process, the majority of manufacturers provide only a 20-year warranty on the material. This is mainly due to the dearth of long-term performance data confirming a longer in-place durability.

Often a compacted clay liner is used instead of geomemebranes. However, recent laboratory (e.g., Albrecht and Benson, 2001) and field investigations (e.g., Albright et al.,

2006) have suggested that the high-plasticity clays commonly used to construct the low-permeability layer are prone to desiccation and cracking, which may lead to significantly reduced performance. This is more common in arid and semiarid environments where the long-term ambient water content of the subsoil is lower than the typical optimum water content used for compaction. In fact, at a test facility located in a semiarid environment near Albuquerque, New Mexico, Dwyer (2003) reported visible desiccation cracks in the compacted low-permeability layer within 15 minutes of installation. Pocatello, Idaho, where this cap would be located, also is a semi-arid environment with precipitation of approximately 12 inches per year. It also has substantial swings in average temperature from winter (the December/January high/low are 34°F/16°F) to summer (July/August high/low of 88°F/50°F). All of these factors could compromise the compacted clay layer.

Because alternative covers rely on soil moisture storage and evapotranspiration rather than HDPE or other barrier to limit infiltration, the main factors that affect their long-term durability are different from those for conventional covers. The durability and long-term performance of alternative covers primarily depend on the establishment of vegetation and protection from wind and water erosion. Both vegetation and erosion monitoring is being performed as part of the post-closure performance monitoring at the FMC facility RCRA ponds. Nine years of monitoring data is available for Pond 8S, which was capped using the combined conventional and ET cover design. Observations from the performance monitoring have indicated that vegetation has been successfully established on that pond cover, as well as the other closed RCRA ponds (see photographs of RCRA pond surfaces in Appendix C). The vegetation has been able to become established without the application of irrigation water, indicating that the natural climate is sufficient for establishing the plant community that a functioning ET cover requires.

One uncertainty that could affect the establishment of vegetation is the presence of phosphine gas vapors in the root zone of an ET cover. The exposure of soil to phosphorus aerosols might change the pH of the soil and create a more acidic layer of soil. Although exposure of plants to elemental phosphorus can have deleterious effects, the effect of oxidation of both phosphine and phosphorus vapors on the soil chemistry is not well documented. However, it is known that the oxidation of these gasses will form phosphoric acid and phosphates. The effect of these reactions on the soil will be affected to large degree by the alkalinity of the soil (buffering capacity) and the flux rate of the gases. The western area borrow soils are highly alkaline with a pH of >8.0 and therefore have a large buffering capacity.

Erosion monitoring as part of the RCRA ponds performance monitoring has not detected any measurable soil loss of the soil layer. This lends more support for the conclusion that vegetation has become established and is effectively holding the soil in-place.

3.5 CONCLUSIONS

The information presented above leads to the following conclusions regarding the comparative performance of conventional (i.e., multi-layered) to ET cover systems at the FMC Plant OU:

- Preventing Direct Exposure – When installed with appropriate institutional controls, conventional and alternative covers are equivalent at preventing direct contact of human and ecological receptors to underlying waste.

- Reducing Infiltration – Field studies, including those performed under ACAP and on-site monitoring data from the alternative covers installed at the FMC Plant site (referenced in Section 2.0) indicate that these covers can result in an equivalent reduction in infiltration when compared to conventional cover systems.

- Design Consideration for the Fate and Transport of Gasses - Given similar circumstances (i.e., PH3 were being generated by the capped waste), gas would build up under the impermeability geomembrane installed in a conventional cover system. However, data collected from the capped former RCRA Pond 16S at the FMC Plant Site and studies preformed regarding the fate of phosphine gas in soils indicate that the air exchange promoted by ET covers may be beneficial to PH 3 neutralization by allowing continuous oxidation and conversion of phosphine gas that is produced by the wastes into non-toxic by-products. In this instance, an ET cover would be superior to a conventional cover system.

- Long-Term Durability – The lack of information regarding the long-term durability of membrane liners and potential for significant damage during placement make ET caps superior in terms of long-term durability. The effect of phosphoric acid generation from oxidation of phosphine on long-term durability of the vegetative cover is not fully understood, but is likely not appreciable given the low phosphine flux rates anticipated.

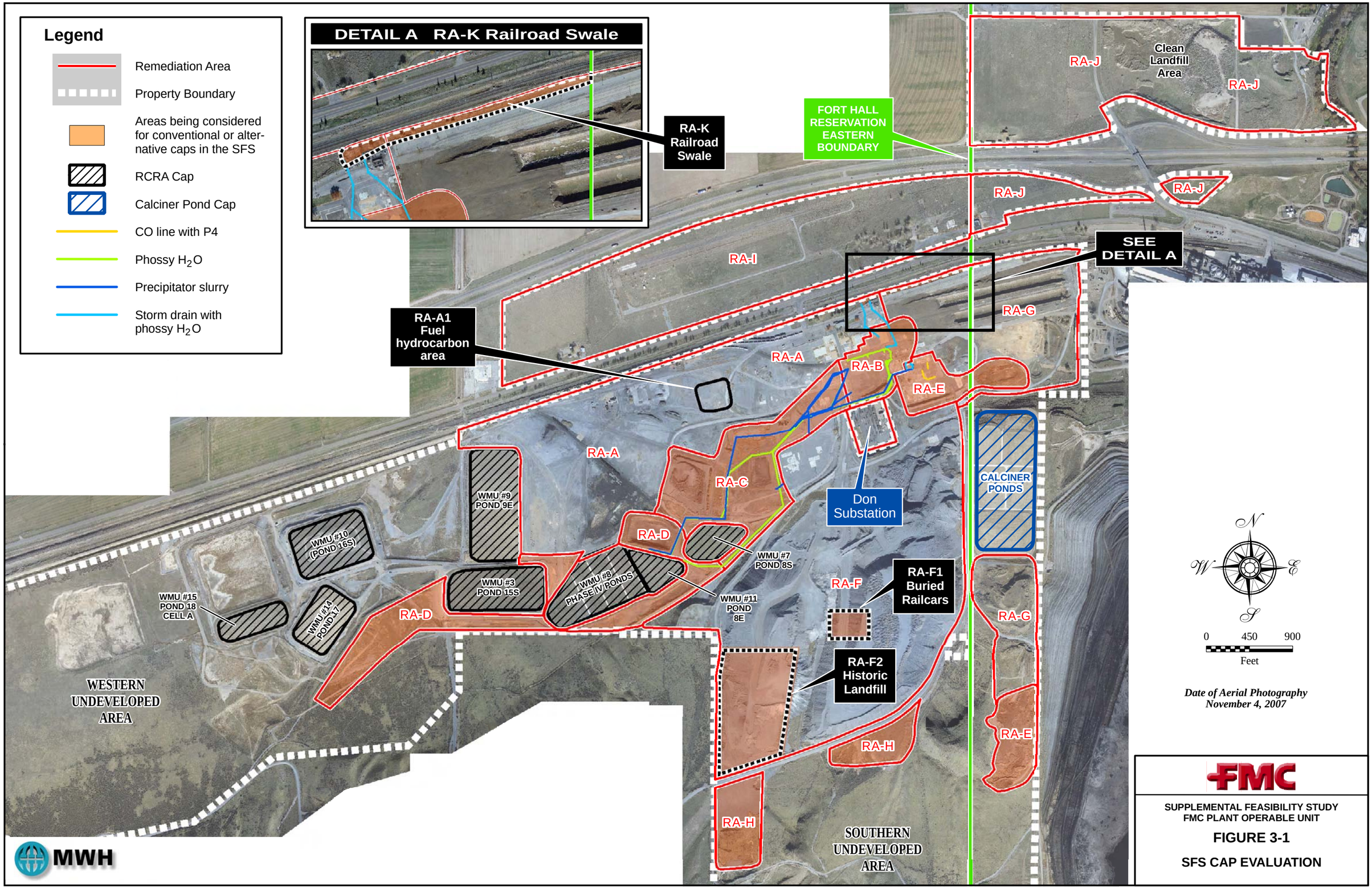
The above performance criteria were developed based on the site-specific RAOs for the FMC Plant OU. These RAOs guide the evaluation and selection of remedial alternatives, including cap placement on various RAs.

Historically, conventional covers have been considered more protective than other approaches. However, FMC Plant OU site-specific performance data (i.e., from the RCRA ponds) and from other sites demonstrate that, once established, alternative covers are equally if not more effective at preventing direct contact and limiting infiltration. Once established, an alternative cover is likely to provide greater long-term protection because of its use of geological materials rather than a single synthetic material (i.e., flexible membrane liners). This concern over the long-term durability of geomembrane

liners was the major reason that the combined conventional and ET cover was used for the FMC facility RCRA ponds.

In the case of performance with respect to the fate and transport of phosphine gas, the information provided in this paper suggests that a cap that “breaths” would favor the degradation of phosphine gas to its non-toxic byproducts. In addition, the areas containing elemental phosphorus that would be capped as part of the remedial action do not have the same site conditions or potential to generate phosphine as found at Pond 16S.

Based on the information presented in this section and the case studies in Section 2.0, it is recommended that an alternative cover consisting of a capillary-break cover, instead of a more conventional multi-layer cap, be considered for capping of RAs described in this section. A conceptual design of the proposed alternative cover is provided in Section 4.0.


Legend
Remediation Area
Property Boundary
Areas being considered for conventional or alternative caps in the SFS
RCRA Cap
Calciner Pond Cap
CO line with P4
Phossy H_2O
Precipitator slurry
Storm drain with phossy H_2O
DETAIL A RA-K Railroad Swale
RA-K Railroad Swale
FORT HALL RESERVATION EASTERN BOUNDARY
Clean Landfill Area
RA-J
RA-J
RA-J
RA-J
RA-I
SEE DETAIL A
RA-G
RA-A1 Fuel hydrocarbon area
RA-A
RA-B
RA-E
RA-A
RA-C
CALCINER PONDS
Don Substation
WMU #9 POND 9E
WMU #10 (POND 16S)
RA-D
WMU #7 POND 8S
WMU #3 POND 15S
WMU #8 PHASE IV PONDS
WMU #11 POND 8E
RA-F
RA-F1 Buried Railcars
WMU #15 POND 18 CELL A
WMU #14 POND 17
RA-D
RA-G
RA-F2 Historic Landfill
WESTERN UNDEVELOPED AREA
RA-H
RA-E
RA-H
SOUTHERN UNDEVELOPED AREA
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900
Feet
Date of Aerial Photography
November 4, 2007
MWH
FMC
SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT
FIGURE 3-1
SFS CAP EVALUATION
FILE Fig 3-1_FMC_SFS Cap Evaluation_609.mxd 6/12/09

Table 3.1. Description of Remediation Areas (RAs) Where Conventional and Alternative Cap Systems Will Be Considered in the SFS

RAs	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs[1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-B	1, 2, and down gradient to include P4-impacted capillary fringe.	This area contains former locations of the furnace building, phossy dock, secondary condenser, and slag pit. Surface and/or subsurface fill within this remedial area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, concrete, asphalt, and silica. Underground piping containing COCs (including P4) exists in RUs 1 and 2. RA-B is considered to be a threat to GW. Fill/Source Materials Considered for HHRA Exposure Scenarios[2]: Slag P4 Precipitator solids Phossy solids Underground Piping Containing P4	SWMU# 5 Slag Pit Wastewater Collection Sump SWMU# 13 Andersen Filter Media (AFM) Washing Unit SWMU# 36 & 55 Rail Car Loading/Unloading, and Phos Dock SWMU# 38 Road segments SWMU# 41 (partial) Stacks and Vents SWMU# 54 Phos Dock Area SWMU# 60 Secondary Condenser/Former Fluid Bed Dryer Area SWMU# 68 Railroad Spurs SWMU# 73 Satellite Areas for Spent Anderson Filter Media SMWU# 74 East AFM Bin Area SMWU# 75 Precipitator Dust Slurry Pots SWMU# 76 Medusa Scrubber Blowdown Collection Tank SWMU# 77 P4 Load Dock, Scrub. Blowdown Sump, and NS Tank SWMU# 78 Washdown Collection Sumps--Furnace Building Area SWMU# 79 Northeast Collection Sump - Furnace Building Area SWMU# 80 Southeast Collection Sump - Furnace Building Area SWMU# 81 Furnace Washdown Collection Tank (V-3600) SWMU# 82 Facility-Wide Wastewater Piping System SWMU# 86 V-3700 Tank and Associated Piping SWMU# 90 V-3800 Tank and Associated Piping SWMU# 91 NOSAP Intercept Tank (Tank T-8010) SWMU#102 Former Slag Pit (prior to slag handling) SWMU# 104 #3 P4 Sump	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.
RA-C	RUs 13, northern portion of 12, eastern portion of 22b, and a small portion of RU 24 between RUs 1 & 2 and RU 22b.	This area contains former phossy/precipitator slurry ponds, the piping corridor between RUs 1 and 2 and 22b (small portions of RUs 12 and 24), and the Pond 8S recovery process. Surface and/or subsurface fill within this area contains P4 (subsurface), phossy solids, precipitator solids, slag, ore, ferrophos, concrete and asphalt. Underground piping containing COCs (including P4) exists in RUs 13, 22b and 24. RA-C is considered to be a threat to GW. Fill/Source Materials Considered for HHRA Exposure Scenarios[2]: Slag Precipitator solids Phossy solids P4 Ferrophos PCDT water residue Underground Piping Containing P4	SWMU# 4 Former 8S Recovery Process SWMU# 25 Pond 0S SWMU# 26 Pond 00S SWMU# 27 Pond 1S SWMU# 28 Pond 2S SWMU# 29 Pond 3S SWMU# 30 Pond 4S SWMU# 31 Pond 5S SWMU# 32 Pond 6S SWMU# 33 Pond 7S SWMU# 34 Pond 10S (Including Pptr. Dust Pile atop pond 10S) SWMU# 38 Road Segments SWMU# 43 Ferrophos Storage Areas SWMU# 53 Old Pond 7S Tree-Line Area SWMU# 56 Drum Storage Area for other Nonhazardous Wastes SWMU# 57 Transformer Salvage Area SWMU# 58 PCB Storage Shed (removed 2000) SWMU# 59 Waste Oil Storage Area SWMU# 62 Area West of Mobile Shop SWMU# 64 (partial) Phossy Waste Pipeline Cleanout Areas SWMU# 65 (partial) Precipitator Slurry Pipeline Cleanout Areas SWMU# 71 Satellite Storage Areas for Waste Degreasing Solvents SWMU# 82 (partial) Facility-wide Wastewater Piping System SWMU# 83 High-pressure steam cleaning Station SWMU# 84 Used Oil Collection Tank SWMU# 107 Portable Storage Tanker for Dielectric Fluid	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher. • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] Since an actual threat to GW has not been demonstrated, the GW RAO is not applicable, however, the SFS will consider a potential GW threat from this area.

Table 3.1. Description of Remediation Areas (RAs) Where Conventional and Alternative Cap Systems Will Be Considered in the SFS

RAs	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs[1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-D	Western portion of 22b and Pond 9S	This area contains former clarified phossy water/precipitator slurry overflow ponds and precipitator slurry ponds. No P4 is present but surface/subsurface fill contains phossy solids, precipitator solids, slag, and ore. RA-D is considered to be a threat to GW. Fill/Source Materials Considered for HHRA Exposure Scenarios[2]: Slag Precipitator solids Phossy solids PCDT water residue Underground Piping Containing P4	SWMU# 6 Area 9S SWMU# 19 Pond 1E SWMU# 20 Pond 2E SWMU# 21 Pond 3E SWMU# 22 Pond 4E SWMU# 23 Pond 5E SWMU# 24 Pond 6E SWMU# 52 Pond 7E	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.
RA-E	RU 8, southern portion of RU 9, and southern portion of RU 16.	This area contains former ore kilns, kiln scrubber ponds, calciners, calciner pond solids stockpile, silica stockpiles, and calcined ore stockpiles. No P4 is present but surface/subsurface fill contains slag, ore, silica, kiln pond solids (subsurface). Underground piping containing COCs (including P4) exists in RU 8 and is listed separately below. RA-E is considered a threat to GW. Fill/Source Materials Considered for HHRA Exposure Scenarios[2]: Slag Ore Calciner pond solids Calcined ore Coke Underground Piping Containing P4	SWMU# 12 Wastewater Treatment Unit SWMU# 17 Calciner Pond Sediment Stockpile SWMU# 35 Three kiln Scrubber Ponds SWMU# 38 Road Segments SWMU# 41 Stacks and Vents (i.e., calciner system) SWMU# 51 Kiln (scrubber) Overflow Pond SWMU# 67 Former Flare Pit for Carbon Monoxide SWMU# 103 New Horizontal Flare Pit	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers • Groundwater Ingestion by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Reduce the release and migration of COCs to the groundwater from facility sources that may result in concentrations in groundwater exceeding risk-based concentrations in groundwater exceeding risk-based concentrations (RBCs) or chemical-specific ARARs, specifically Maximum Contaminant Levels (MCLs), or reduce to site-specific background concentrations if those are higher.
RA-F1 (Buried Railcars)		In 1964, 21 railcars containing an estimated 10 to 25% P4 sludge were placed at the southern edge of the slag pile and covered with native soil. The railcars were then covered with 80 to 120 feet of slag as the slag pile progressed to the south. RU 19c is considered to be a potential threat to GW[3]. Fill/Source Materials Considered for HHRA Exposure Scenarios: Slag Phossy solids P4	None	• Hypothetical future worker exposure to External Gamma Radiation	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] Since an actual threat to GW has not been demonstrated, the GW RAO is not applicable, however, the SFS will consider a potential GW threat from this area.

Table 3.1. Description of Remediation Areas (RAs) Where Conventional and Alternative Cap Systems Will Be Considered in the SFS

RAs	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs [1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-F2 (Former Landfill)		This sub-area is located within the southwestern corner of the slag pile (RU 19). Landfill operations within this sub-area (RU 19b) began at the inception of plant operations in 1949 and ceased in 1980. Wastes placed in RU 19b included slag, office wastes (consisting of office and lunchroom solid wastes), industrial wastes (consisting of asbestos, spent solvents, oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes, and AFM) furnace rebuild/digout wastes (consisting of furnace feed materials, carbon materials, concrete, rocks, and debris), IWW sediments, and baghouse dust. These wastes are covered by 50 - >100 ft of slag. RU 19b is considered to be a potential threat to GW [3]. Fill/Source Materials Considered for HHRA Exposure Scenarios: Slag Office wastes Industrial wastes – asbestos wastes, spent solvents, and oily residues, transformer oil, kiln scrubber solids, phosphorus-bearing wastes, fluid-bed dryer wastes AFM Furnace digout/rebuild wastes	SWMU# 44 Landfill (old)	• Hypothetical future worker exposure to External Gamma Radiation	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4.
RA-H	RUs 17 and 18	This area contains the active plant landfill (RU 18) and the construction/demolition debris landfill (RU 17). Surface and subsurface fill within this area contains solid waste including plant trash, Andersen filter media (AFM), asbestos, empty containers, concrete, carbon, and furnace feed materials (ore, silica, coke). RA-H is considered to be a potential threat to GW. [3] Fill/Source Materials Considered for HHRA Exposure Scenarios: Slag Furnace feed materials (ore, silica, coke) Office wastes Packaging materials AFM Asbestos containing materials Carbon	SWMU# 38 Road segments SWMU# 45 Landfill (also referred to as Solid Waste Landfill) SWMU# 89 Roadway Landfill	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Dermal Absorption by Hypothetical Future Workers • Inhalation of Fugitive Dust by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent dermal contact of soils containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent inhalation of fugitive dust containing COCs at levels that pose an excess cancer risk above 1x10-4 and an excess non-cancer risk HQ of 1.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] Since an actual threat to GW has not been demonstrated, the GW RAO is not applicable, however, the SFS will consider a potential GW threat from this area.

Table 3.1. Description of Remediation Areas (RAs) Where Conventional and Alternative Cap Systems Will Be Considered in the SFS

RAs	RUs	Description and Fill/Source Materials	Associated RCRA SWMUs [1]	Exposure Scenarios of Concern	RAOs Which Remedial Alternatives Must Address
RA-K (Railroad Swale)	22c	This sub-area is located along the northeastern border of the FMC Plant Site and was used for stormwater retention. In addition to stormwater, the Railroad swale (RU 22c) also received an intermittent flow of phossy water and is known to contain low levels of P4 and phossy solids. In the late 1980s, the railroad swale was excavated and backfilled with slag and ore. RU 22c is considered to be a potential threat to GW [3]. Fill/Source Materials Considered for HHRA Exposure Scenarios: Slag Phossy solids P4 Ore	SWMU# 18 Railroad Swale	• Hypothetical Future Worker Exposure to External Gamma Radiation • Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers	• Prevent external exposure to radionuclides in soils at levels that pose estimated excess cancer risk greater than 1x10-4. • Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1.
UG Piping		This sub-area includes underground piping that remains in place and may contain P4, precipitator solids, and/or phossy solids. This UG piping is believed to exist in RUs 1, 2, 3, 8, 12, 13, 22b and 24. UG Piping is considered to be a potential threat to GW [3]. Fill/Source Materials Considered for HHRA Exposure Scenarios[2]: P4 Precipitator solids Phossy solids	SWMU# 64 Phossy Waste Pipeline Cleanout Areas SWMU# 65 Precipitator Slurry Pipeline Cleanout Areas	• Incidental Ingestion of Soils and Solids by Hypothetical Future Workers • Hypothetical Future Worker Exposure to Fire • Inhalation of Airborne Phosphorus Reaction Products by Hypothetical Future Workers	• Prevent ingestion of soils containing COCs at levels that pose estimated excess risks above 1x10-4 and an excess non-cancer risk HQ of 1. • Prevent direct exposure to elemental phosphorus in shallow soils and underground piping at levels that, if encountered during intrusion into the subsurface, would support vigorous and sustained fire and resultant air emissions that represent a significant risk to human health and the environment. Elemental phosphorus has been designated a principal threat waste where present at such levels in shallow soils and underground piping and shall be remediated through removal and treatment unless a non-removal and treatment remedy is justified using the nine criteria in accordance with the NCP. • Prevent inhalation of phosphoric acid aerosols resulting from combustion of P4 at levels that pose an excess non-cancer risk HQ of 1.

[1] RCRA SWMUs do not necessarily contribute to the Remediation Area (RA) risk, but are identified here to integrate RCRA corrective action into the SFS under the "one clean-up" initiative.
[2] Risks associated with exposure to the contents of underground piping runs are evaluated separately from risks associated with exposure to other surface and subsurface fill/source materials identified in an RU.
[3] Since an actual threat to GW has not been demonstrated, the GW RAO is not applicable, however, the SFS will consider a potential GW threat from this area.

TABLE 3-2

SEED MIX USED ON RCRA-CLOSED POND CAPS
FMC Corporation, Pocatello, Idaho

Seed	lb/acre [1]	% of mix	Min. Pure/Germ
Indian Ricegrass	4	19.5	98/85
Rubber Rabbitbrush	4	19.5	10/65
Covar Sheeps Fescue	4	19.5	98/85
Great Basin Sage Brush	3	14.6	25/50
Sand Dropseed	2	9.8	90/75
Desert Needlegrass	1	4.8	60/50
Lewis Blue Fax	1	4.8	98/70
Desert Globemallow	0.5	2.5	98/50
Sulpher Buckwheat	0.5	2.5	25/25
California Poppy	0.5	2.5	98/80
Totals	20.5	100	

[1] Applied with a drill with 500 lb/acre of 6-20-20 (N-P-K) fertilizer.

SECTION 4.0 Preliminary Alternative Cover Design

This section presents the proposed preliminary design for the alternative cover to be considered in the various remedial alternatives for the FMC Plant OU SFS. The preliminary design is based on average climatic conditions of the site and soil moisture storage properties of the borrow source to be used in the cover's construction. The preliminary cover design will be used to develop engineered cost estimates for remediation of the FMC Plant OU. It is assumed that a detailed design supported by numerical modeling will be performed during the RD once a record of decision (ROD) is approved for the site.

4.1 CONCEPTUAL DESIGN

Measurements of water balance parameters were used to develop a conceptual model of water flow through alternative cover systems. These are the primary parameters used to prepare conceptual alternative cover designs for caps proposed for constructed in arid and semiarid environments. Water transport through an alternative cover is based on fundamental physical processes that govern the flow of water in the vadose (unsaturated) zone.

Following construction and seeding, initial root development will take place during the growing season, and precipitation that occurs during the spring and summer will be removed through evaporation and to a lesser extent transpiration, retained in the soil profile as storage, or transmitted downward as potential recharge (i.e., drainage). During the initial post-construction timeframe, drainage could occur in response to summer precipitation and wet antecedent moisture conditions (i.e., water used during construction) combined with an undeveloped rooting system. Installation of a thin surface layer comprised of topsoil mixed with gravel should encourage revegetation through moisture retention and decrease the potential for early drainage.

As fall approaches, evapotranspirative fluxes will decrease in magnitude and the amount of soil water stored within the cover should reach a minimum since the majority of water that infiltrates will be consumed. During winter, precipitation will be comprised of mixed amounts of snow and rain (depending on latitude and elevation), which will infiltrate into the soil, evaporate, sublimate, or be stored as a winter snowpack. Soil moisture storage generally reaches a maximum during the winter since vegetation is dormant and evaporative fluxes are at a minimum.

For conditions that lead to an ephemeral or small snowpack, water may infiltrate into the cover as the snow melts if the upper surface is not frozen. However, in Pocatello, Idaho where this alternative cover is proposed, the frost line depth is approximately 3 feet below ground surface through the winter months of December, January, and February. This means that water derived from thawing and snow melt during the winter months primarily would be removed from the cover by sublimation, evaporation, and runoff. A

minor amount would be retained in the soil profile. Water derived from snowmelt in the early fall and late spring will be removed through evaporation, retained in the soil profile as storage, or transmitted as runoff. If the ground is relatively thawed, infiltration would occur and drainage could develop if the storage capacity of the cover material is exceeded (e.g., an exceptionally wet winter characterized by repeated snowfall and melting in which the rate of water flow into the cover exceeds the rate of evaporation and storage potential). Drainage can be eliminated if a capillary break is present (i.e., due to increased storage capacity of the overlying fine-grained soils).

For conditions that lead to the development of a large snowpack, the quantity of water will decrease in magnitude through sublimation. As spring approaches and the snow begins to melt, water will be transmitted downward if the ground is unfrozen. If melting of the snowpack occurs relatively quickly, early-on during the growing season, and the cover is not sufficiently designed to store the winter precipitation, conditions that lead to drainage could develop. Surface runoff would occur for instances in which the ground is frozen or the rate of infiltration exceeds the saturated hydraulic conductivity of the surface layer. However, if melting of the snowpack is prolonged, the likelihood that the storage capacity of the system will be exceeded significantly decreases since roots will begin consuming water, and increased evaporative fluxes may result in an upward gradient of soil moisture. A portion of the water retained as storage during the winter, which is not consumed through sublimation and evaporation or transmitted as runoff, will be consumed during the growing season.

The transition from spring to summer results in increased evapotranspiration and a decrease in soil moisture. As the vegetation becomes fully established, the cover system will reach a state of dynamic equilibrium in which the rate of infiltration will equal the rate of water removal, and the available storage capacity of the cover (if adequately designed) would be sufficient to significantly reduce infiltration except perhaps during exceptionally wet periods. The presence of deep rooted vegetation, and increased storage capacity provided by a capillary break, would enhance evapotranspirative fluxes, and reduce the potential for drainage to occur. To further minimize the potential for drainage, the region/area specific seed mix should incorporate a combination of cool and warm season grasses and shallow-rooting shrubs to maximize the consumption of water (i.e., root water uptake) stored in the subsurface.

4.2 CLIMATE RECORD

Climate data was gathered from the Pocatello WSO Airport weather station (Station 107211). For the purpose of the preliminary design, the maximum winter precipitation, for the period of record (1939 to 2008), was used to provide an estimate of the worst-case amount of water storage that would be required. The maximum total precipitation for the winter (December, January, and February) months represents precipitation that would not be removed by evapotranspiration and thus would be required to be stored by the cover until plant growth and warmer temperatures began to remove water through evapotranspiration in the spring. The total maximum amount of precipitation for the months representing the winter period is 6.16 inches compared with an average of 3.07

inches. The maximum winter precipitation of 6.16 inches was used in the preliminary cover thickness calculations.

4.3 COVER MATERIALS

Five samples of potential borrow source material from the western borrow area were collected and submitted for geotechnical and hydrogeologic characterization. Geotechnical characterization included grain size analysis (sieve and hydrometer (ASTM D422), and Standard Proctor Compaction (per ASTM D698). Hydrogeologic characterization included saturated permeability testing (per ASTM D5084) at between 80% and 85% of the maximum dry density (i.e., Standard Proctor) and capillary moisture testing (ASTM D3152).

The samples were separated into the percentage of gravel, sand, silt, and clay and classified according to predominant soil type. The borrow materials were classified as either silt, calcitic silt, or clayey silt. The average maximum dry bulk density was 101.75 lbs per cubic foot (pcf) with optimum moisture content of 18%.

At the time of the design of the RCRA ponds, hydrogeological data had not been collected. As such, published literature values were used for determining the water storage capacity of the soils for use in performance modeling of the proposed caps. To justify the absence of site specific data, the model used conservative values for characterizing the materials. Therefore, the RCRA pond caps' design represents an overly conservative assessment of required cover thicknesses. For example, the assumed hydraulic conductivity of the top soil layer (storage layer) was 9.35 x 10-4 cm/sec, whereas, the permeability testing from the borrow source yielded an average hydraulic conductivity of 5x10-5 cm/sec for samples compacted to 85 percent standard Proctor and 6.6 x 10-5 cm/sec for samples compacted to 80-percent standard Proctor. This lower actual hydraulic conductivity would result in the cover having higher actual runoff and lower infiltration rates, compared to those used in the RCRA cap modeling.

Capillary-moisture relationship testing was performed to determine the soil moisture storage capacity of the borrow material. Based on the test results, the difference in moisture content of the soil between saturation (approximated to be field capacity) and -15,000 cm of pressure (approximated to be wilting point) was determined. These provided an approximation of the total amount of water that can be stored in the cover. For the purpose of the preliminary design, the results for the samples remolded to 85% of modified Proctor were used, due to difficulties with achieving lower densities in the field. The results of the test yielded an average water storage capacity of 28.5-percent.

4.4 WATER STORAGE CALCULATIONS

The thickness of the storage layer for the preliminary design was determined using the following equation:

$$T \geq \frac{P_0}{\vartheta_u} = 21.5\ inches$$

Where:
P_0 = precipitation outside growing season (winter months [6.18 inches);
ϑ_u = unit available storage $= \theta_{fc} - \theta_{wp}$ = 28.5%

Where:
θ_{fc} = water content at field capacity
θ_{wp} = water content at wilting point

Based on this calculation, a storage layer with minimum thickness of 24 inches would be necessary to store the anticipated winter precipitation in the Pocatello area. Although a safety factor of 1.5 is commonly used for this calculation, this calculation conservatively assumes that all precipitation that falls to the surface would infiltrate and thus would need to be stored. In actuality, as described earlier, a portion of this precipitation would runoff and a portion some would evaporate/sublimate. Surface layers having lower saturated hydraulic conductivity, as is the case with the silt from the Western Borrow Area of the FMC Plant OU, will generate more runoff, less infiltration into the surface layers, and less percolation (Khire et al., 2000). In addition, this calculation also does not take into account the presence of a capillary break, which will add a factor of storage capacity to this upper layer.

A capillary break would be used for alternative covers at the FMC Plant OU for two reasons: 1) the availability of large amounts of variably sized crushed slag ideally suited as a capillary barrier material; and 2) capillary break enhances storage capacity of the finer textured storage layer (http://www.rtdf.org/public/phyto/minutes/031004/pdf/benson-ses1.pdf). A study conducted by Khire et al. (2000) found that for their given soil thickness of 1 m the presence of a capillary break increased the storage capacity of soil by 3 inches. This effect may be greater for the FMC site due to the presence of non-plastic silts in the borrow area, which greatly enhances the effect of capillary barriers (http://www.rtdf.org/public/phyto/minutes/031004/pdf/benson-ses1.pdf).

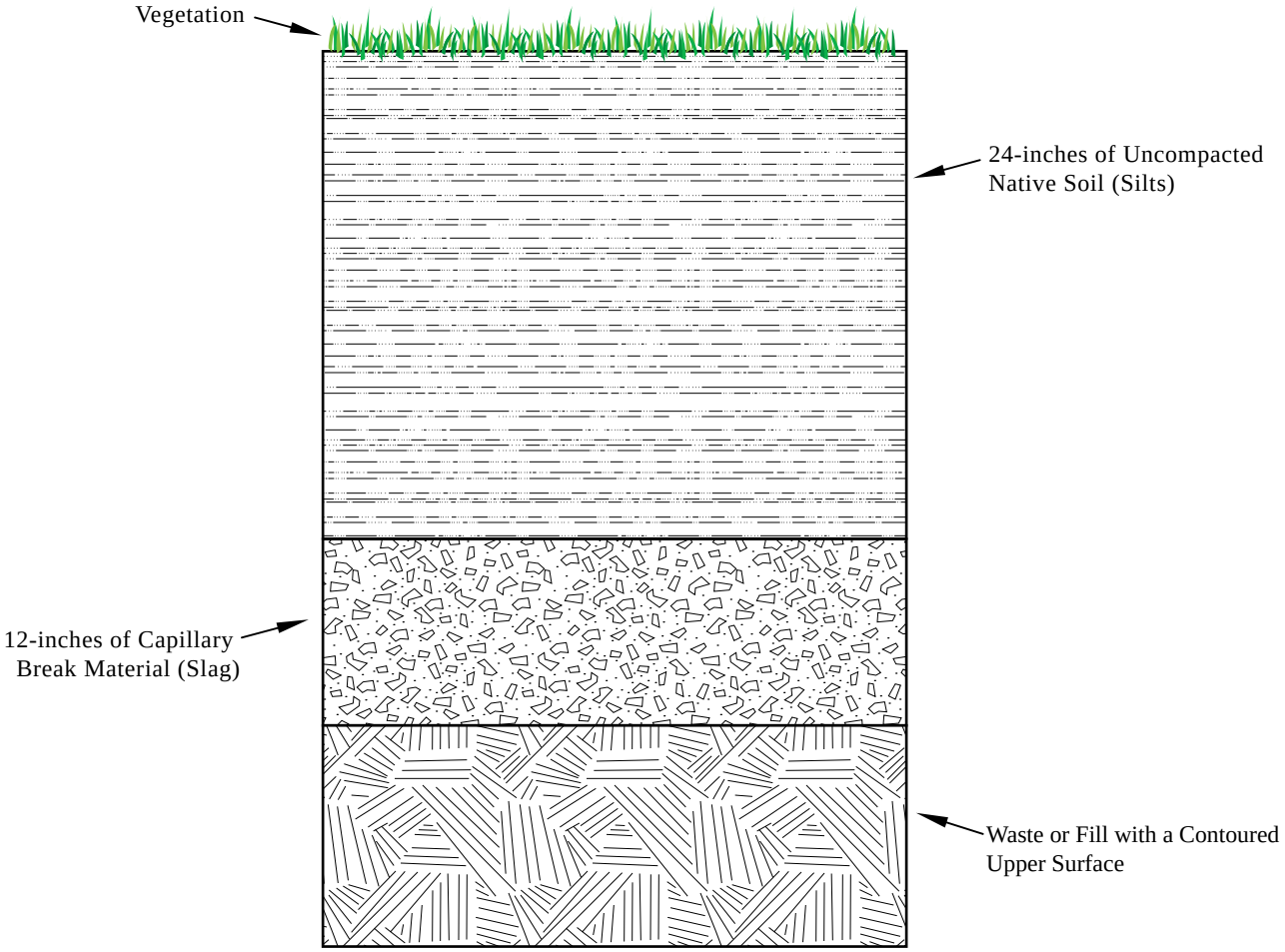
4.5 PRELIMINARY COVER DESIGN

Based on the water storage calculations, it was determined that a 24-inch soil storage layer is appropriate for the preliminary ET cover design. As described above, a capillary break will also be incorporated into the design to increase the storage capacity of the cover. A 1 foot thick layer of coarse crushed rock (slag or gravel) has been shown to be

sufficient to serve as a capillary break (Khire et al., 2000). In addition to serving as a capillary break, the crushed slag will also serve as a biointrusion layer (Dwyer et al., 2007). It is anticipated that the covers would be constructed with a minimum of 3% slope to promote surface drainage while at the same time reducing the potential for erosion. The cover will be revegetated with native plant species with sufficient rooting depths and overlapping grow seasons to maximize evapotranspiration. Experience with the current caps on the RCRA ponds indicate that vegetation at the can be successfully established without the necessity for supplemental irrigation, although if necessary, water may be available from other remedial activities at the site (e.g., a groundwater pump and treat system). Figure 4-1 shows the preliminary ET cover design to be used during the SFS detailed evaluation.

The preliminary design proposed in this paper was developed for the purpose of evaluating the performance and cost of the assembled alternatives in the SFS. Prior to implementing any alternative utilizing the proposed alternative cover, cover performance modeling will be performed to develop a detailed design during the Remedial Design. Based on the results of the modeling, the cover design, specifically the thickness of the storage layer, may be modified to meet regulatory requirements.

ET CAP



FMC

SUPPLEMENTAL FEASIBILITY STUDY
FMC PLANT OPERABLE UNIT

FIGURE 4-1

ANTICIPATED ET CAP DESIGN

MWH

FILE *Fig Fig 4.1 FMC_AnticipatedCap.ai 6/11/09*

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Appendix A

RCRA Design and Estimation of Percolation Rates Through the Pond 8S RCRA Cap (Appendix F to the *Pond 8S Closure Plan – May 1998*)

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1. INTRODUCTION

A modified RCRA cap is proposed in lieu of the EPA-recommended guidance cap (or RCRA-guidance cap) for the closure of Pond 8S at the FMC facility in Pocatello, Idaho. This Appendix describes the numerical model developed to evaluate the hydrologic performance of the proposed cap and to demonstrate its equivalency with the RCRA-guidance cap shown in Figure 1.

The hydrologic performance of the proposed cap and RCRA guidance cap was evaluated using the HELP computer program Version 3 (EPA 1994a, b) and the UNSAT-H computer program Version 2.03 (Fayer and Jones, 1990). The HELP model is recommended by EPA to evaluate the hydrologic performance of surface barrier designs. However, the HELP model has major limitations in its applicability to the proposed closure cap. To overcome these limitations, the HELP and UNSAT-H programs were used in conjunction to evaluate the performance of the proposed cap.

This Appendix is organized as follows. Section 2 presents a description of the proposed cap. Section 3 describes the approach and computer codes used to evaluate the performance of the cap, and the rationale behind this approach. Section 4 presents a detailed description of the input parameters and assumptions used in the different models. Section 5 discusses the modeling results. Section 6 concludes with a brief summary of this modeling effort and Section 7 presents a list of references.

2. DESCRIPTION OF THE PROPOSED CAP

The proposed closure cap for Pond 8S the FMC facility in Pocatello, Idaho was designed to meet the following requirements:

1. Design the cap for a minimum functional life of 500 years.
2. Provide long-term minimization of migration of liquids through the cap.
3. Minimize the potential of biointrusion through the cap
4. Promote drainage and minimize erosion or abrasion of the cover.
5. Provide for drainage monitoring to check water balance at any time to evaluate the potential for leaks through the cap.

To meet the above requirements, the proposed closure cap will consist of the following layers from top to bottom (Drawing 100-C-204):

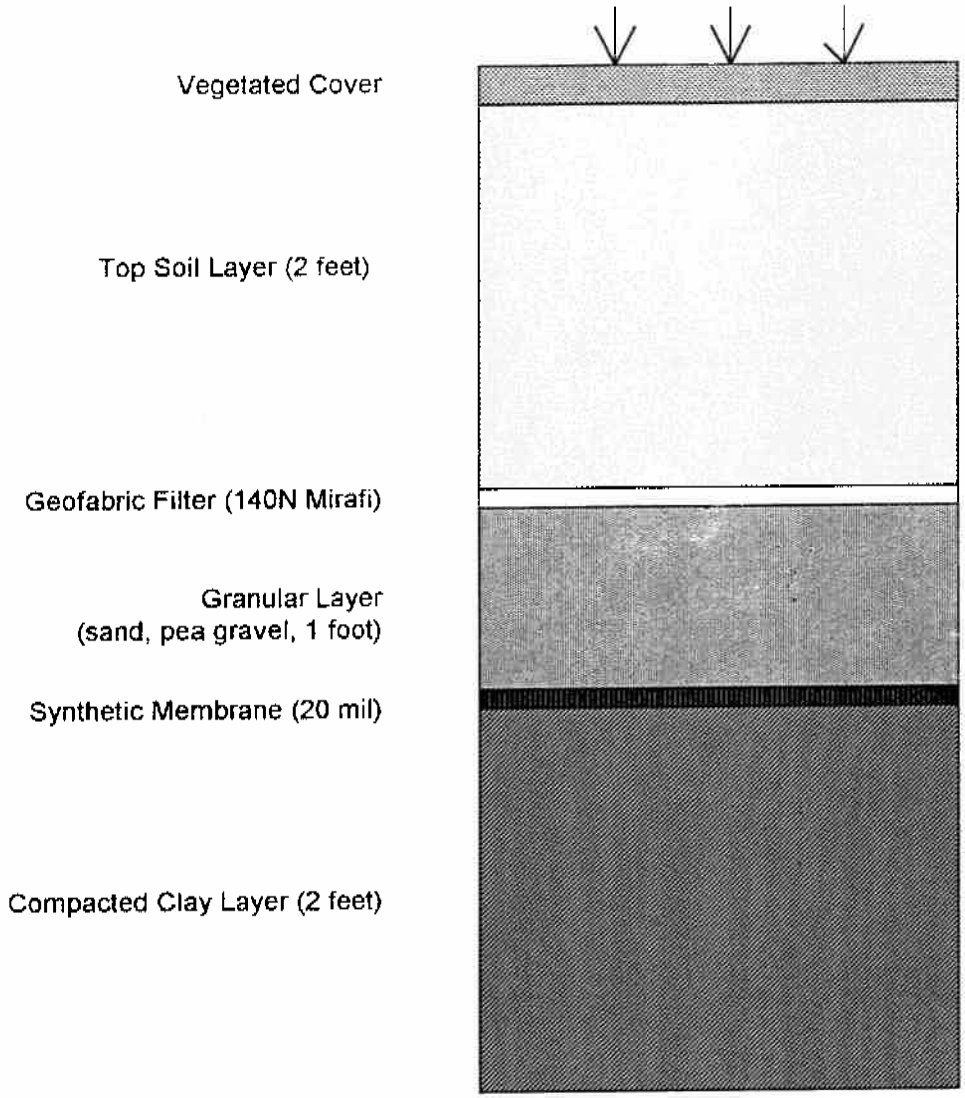

Figure 1
RCRA Guidance Cap

- Topsoil consisting of 12 inches of native topsoil with 15% by weight pea gravel admixture, underlain by 30 inches of native topsoil without pea gravel. These two layers serve several important purposes including:

    a. provide a storage medium for the retention of infiltrating water and its subsequent removal by evapotranspiration, and

    b. allow for the natural growth of a vegetative cover which will enhance the removal of moisture from the soil and decrease wind and water erosion.

  The upper 12 inches include 15% by weight pea gravel which will serve to stabilize the cap surface and hence reduce erosion losses. The 15 % by weight proportion is based on wind tunnel tests conducted for the Hanford site in Washington State (Ligotke, 1993).

- Graded filter material consisting of 6 inches of coarse sand and 6 inches of 4" minus graded crushed and screened slag. This two-layer graded filter will prevent the overlying fine-textured soil from moving downward and accumulating in the coarse slag layer and/or the geofabric above the lateral drainage layer. This will assure the continued functionality of the capillary barrier.

- 18 inches of crushed and screened coarse slag. The purpose of this layer is to control biointrusion and to present an obstacle to inadvertent human intrusion. The general crushed slag product produced at the site will be comprised of angular slag, well-graded material, ranging in particle size from 1-1/2 inches to a maximum size of 12 inches.

- Sand filter material consisting of 12 inches of coarse sand to be placed underneath the coarse slag biointrusion layer to protect the underlying synthetic materials.

- Drainage layer consisting of geofabric and geosynthetic drainage net (Geonet). This layer and all underlying layers will form the secondary barrier of the Pond 8S cap.

- Flexible membrane liner (FML), HDPE having a minimum thickness of 60-mil.

- Low Hydraulic Conductivity Layer consisting of a Geosynthetic Clay Liner (GCL) having an equivalent hydraulic conductivity to that of a 2-ft thick clay layer. The material will consist of Gundseal HDPE/Bentonite composite liner or equivalent. The GCL is to be installed over a prepared subgrade which includes a 6 inch sand foundation layer over the slag fill.

In effect, the proposed cap consists of two main components:

1. A capillary barrier comprised of the topsoil, the graded filter material and the biointrusion layer. The purpose of the capillary barrier in semi-arid climates such as that present in

Pocatello is to limit the rate of infiltration through the cap and ensure the longevity of the cap.

2. A secondary barrier underlying the capillary barrier comprised of the drainage layer and the synthetic liners. The purpose of the secondary barrier is to act as a contingency barrier that will further decrease the net infiltration into the waste area by allowing for the lateral drainage of the excess infiltration through the capillary barrier.

3. METHODOLOGY

The performance of the proposed cap and RCRA guidance cap was evaluated using the HELP computer program Version 3 (EPA 1994a, b) and the UNSAT-H computer program Version 2.03 (Fayer and Jones, 1990). The HELP model is recommended by EPA to evaluate the hydrologic performance of surface barrier designs. However, the application of the HELP model to the proposed closure cap has two major limitations. First, the HELP model assumes a time invariant evaporative zone depth which may not be a valid assumption for semi-arid climates similar to that at Pocatello. Second, the equations used in the HELP model to simulate flow in the unsaturated zone cannot accurately model flow through the capillary barrier proposed for Pond 8S. On the other hand, the computer code UNSAT-H is capable of simulating flow through a barrier layer, however does not account for any lateral drainage from the cap and cannot simulate flow though the FML. To overcome the limitations of each of these two programs, the hydrological performance of the proposed cap was evaluated in two steps. In the first step, flow through the capillary barrier (top soil to the sand foundation layer underneath the biointrusion layer) was simulated with the UNSAT-H computer program. In the second step of the analysis, the HELP program was used to simulate flow through the secondary cap underneath the barrier cap (foundation sand to the GCL). In this latter step, the daily percolation through to the bottom of the capillary cap resulting from the UNSAT-H analysis was incorporated into the HELP model input.

In addition to the approach presented above, the proposed cap was also modeled in its entirety using the HELP model for comparison purposes. Furthermore, to demonstrate the equivalency of the proposed cap to the RCRA guidance cap, the RCRA guidance cap was also evaluated using the HELP model. The input parameters and model results are described in Sections 4 and 5 of this Appendix. The computer programs HELP and UNSAT-H are briefly described in the following paragraphs.

The HELP program, Versions 1, 2 and 3, was developed by the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS for the U.S. Protection Agency (EPA). HELP is a quasi two-dimensional hydrologic model which performs water balance analyses to predict water movement through landfills and other solid waste containment facilities. The program uses

empirical equations to estimate evapotranspiration, surface runoff, surface storage, snowmelt, lateral subsurface drainage, soil moisture storage, and infiltration from climatological, soil, and design specification data.

UNSAT-H Version 2.03 (Fayer and Jones, 1990) was developed at the Pacific Northwest Laboratory for assessing the water dynamics of arid, near-surface waste disposal sites. The model simulates the flow of water and heat through unsaturated multi-layer porous media. Flow of liquid water and water vapor are calculated based on the one-dimensional Richards' equation and Fick's law of diffusive vapor, respectively. UNSAT-H uses time-dependent boundary conditions at the ground surface, calculated from daily meteorological data. UNSAT-H has been used to evaluate the performance of capillary barrier systems at Hanford (Fayer et al., 1992; Olson, 1996, DOE, 1996).

4. INPUT DATA

4.1 Weather Data

Climatological data for the UNSAT-H and the HELP programs consist of daily rainfall, temperature, and solar radiation data. Because the length of the climatological data records is much shorter than the 500-year functional life of the proposed cap, daily rainfall, temperature and radiation data were synthetically generated. The routine used to generate the climatological data was developed by the USDA Agricultural Research Service (Richardson and Wright, 1984) and is described in the HELP manual (EPA, 1994a). The generating procedure is designed to preserve the dependence in time, the correlation between variables and the seasonal characteristics of the actual weather data at the specified locations.

The 500-year synthetic data were generated by estimating first the statistical rainfall distribution data at the site from rainfall data recorded at the Pocatello Municipal Airport (National Weather Service Station No. 24156) for the period 1948 to 1991. Table 1 gives the estimated parameters a and b defining the gamma function that describes the probability distribution of daily rainfall used in the synthetic data generator in HELP. These values are estimated for each month of the year. Based on these values the daily rainfall, daily minimum and maximum temperature and daily solar radiation were generated for the 500-year period using the routines developed the USDA Agricultural Research Service (Richardson and Wright, 1984).

TABLE 1
MEAN PRECIPITATION AND *a* AND *b* VALUES
OF THE G-FUNCTION DISTRIBUTION OF DAILY RAINFALL IN POCATELLO

Month	Pocatello WSA AP (1948-1991)		
	Precipitation	*a*	*b*
Jan.	1.08	0.711	0.125
Feb.	0.87	0.771	0.109
Mar.	1.17	0.789	0.144
Apr.	1.15	0.842	0.166
May	1.31	0.646	0.216
Jun.	1.01	0.668	0.222
Jul.	0.50	0.530	0.242
Aug.	0.61	0.555	0.243
Sep.	0.72	0.703	0.215
Oct.	0.85	0.575	0.282
Nov.	1.09	0.905	0.131
Dec.	1.09	0.786	0.127

4.2 Properties of Materials Used in Proposed Cap

As notes in Section 2. the proposed cap was evaluated using a two-step approach combining the UNSAT-H and HELP computer programs. The first step simulates flow through the capillary barrier using the UNSAT-H program. In the second step, the net infiltration from the capillary barrier is then used as part of the input into the HELP model comprising of the secondary barrier underneath the biointrusion layer. For comparison purposes, a HELP model was developed for the entire proposed cap as well as for the EPA RCRA guidance cap.

This section presents the input parameters and assumptions used in all 3 models described above. A list of the input parameters used in the UNSAT-H/HELP model and the HELP model for the proposed cap are listed in Table 2. In general, these parameters were based on field data when available, or on literature value for comparable materials. Of the parameters listed in Table 2, the thickness, porosity and saturated hydraulic conductivity parameters are common to both models, UNSAT-H and HELP. The Van Genuchten parameters n, α and residual moisture content, θ_r, are needed for the UNSAT-H model, while the field capacity and the wilting point are required in the HELP model only. In general, these latter two parameters were set equal to default HELP values found in the HELP documentation (Table 4, EPA, 1994b) for comparable materials.

Key input parameters for the analysis of the capillary barrier cap design are the hydraulic conductivity and the moisture characteristic curves of the soils used in the cap. The moisture characteristic curves provide the relative hydraulic conductivity and the matrix potential, or suction head, as a function of the degree of saturation. Different functions are used in the literature to represent these curves. In the present analysis, the moisture characteristic curves were defined using the water retention functions proposed by van Genuchten (1978), which require assumptions of the three constants, n, α, and θ_r. The values of these constants were determined from published values in the literature for comparable soils (Carsel and Parrish, 1988).

A brief discussion of the parameter values listed in Table 2 is presented below:

Layer 1-- Top Soil: The thickness of top soil layer used in the UNSAT-H and HELP models was conservatively set to 36 inches which is the 42 inches of top soil that will be placed over Pond 8S less the estimated 500-year water and wind erosion losses of 6 inches. The saturated hydraulic conductivity was set to 9.35×10^{-4} cm/s which is approximately two times the HELP default value for fine sandy loam (page 30, Table 4, EPA, 1994b). Default HELP values were also used for the porosity, field capacity, and wilting point. The Van Genuchten parameters used to define the characteristic curves of this soil material were based on published literature values for comparable soils (Carsel and Parrish, 1988). Laboratory testing conducted on the locally available soils that will be used for this layer indicate that the above parameter values are conservative.

Layer 2-- Sand Filter (Transition) Layer: Layer 2 is a transition layer consisting of 6 inches of coarse sand. The saturated hydraulic conductivity, porosity, field capacity and wilting point values used in the numerical model were set to the default HELP values for coarse sand. The Van Genuchten parameters used for this layer were set equal to the suggested values for sand (Carsel and Parrish, 1988).

TABLE 2
PROPERTIES OF THE MATERIALS
USED FOR THE PROPOSED CAP IN THE UNSAT-H AND HELP MODELS

Layer	Thickness (in)	Saturated Conductivity (cm/s)	Porosity	Residual Moisture Content[1]	n[1]	a[1]	Field Capacity[2]	Wilting Point[2]
Top soil	36	9.35×10^{-1}	0.473	0.067	1.41	0.015	0.222	.105
Sand Transition Layer	6	0.01	.417	0.04	2.68	0.15	0.045	0.018
Crushed Slag Transition Layer	6	0.1	.397	0.03	2.68	1.0	0.032	0.013
Coarse Slag	18	1.0	.375	0.006	3.0	10.0	0.022	0.01
Foundation Layer	12	0.01	.417	0.04	2.68	0.15	0.045	0.018
Geonet	0.2	10	.85	-	-	-	.01	.005
FML	0.04	2×10^{-12}	-	-	-	-	-	-
GCL	.17	3×10^{-9}	.75	-	-	-	.747	.4

[1] Parameters required for the UNSAT-H model only

[2] Parameters required for the HELP model only

Layer 3-- Gravel Filter (Crushed Slag Transition) Layer: Layer 3 is a transition layer consisting of 6 inches of 4" minus gravel or graded crushed and screened slag. In the numerical model, Layer 3 was assumed to have soil properties similar to that of gravel. Therefore, the layer's saturated hydraulic conductivity was set to 0.1 cm/s. The van Genuchten parameters were based on the values used for the engineered barrier study at the 200 Areas at Hanford, Washington (Appendix C, DOE, 1996). Default HELP values were used for the porosity, field capacity, and wilting point.

Layer 4-- Coarse Slag: Layer 4 consists of 18 inches of crushed and screened coarse slag, ranging in particle size from 1-1/2 inches to a maximum size of 12 inches. The hydraulic conductivity of this layer was assumed to be 1 cm/s, one order of magnitude greater than that of Layer 3. The van Genuchten parameters was set equal to the values used for the biointrusion layer of the engineered surface barrier at the 200 Areas at Hanford, Washington (Appendix C, DOE, 1996).

Layer 5-- Sand Filter Layer: Layer 5 consists of 12 inches of coarse sand. Its hydraulic conductivity was assumed to be identical to that of Layer 2.

Layer 6-- Geonet Drainage Layer: From the manufacturer's specifications, the thickness and transmissivity of the geonet at 10,000 psf compressive are 0.2 inches and 0.002 m^2/s, respectively. These values correspond to a saturated hydraulic conductivity of 40 cm/s. To provide some measure of conservatism, the geonet hydraulic conductivity in the HELP model was set to 10 cm/s.

Layer 7-- Flexible Membrane Liner (FML): The thickness of the FML used in the model is 40 mil which is less than the minimum of 60 mil proposed for the cap. The hydraulic conductivity of the FML was set equal to 2×10^{-12} cm/s, as specified in the manufacturers specifications. This value is also an order of magnitude larger than the HELP default value for HDPE. The placement quality of the FML was assumed to be good. Because the design life of the cap is quite long, the pinhole density was assumed to be "poor" on a scale ranging from "excellent" to "poor", which corresponds to 10 holes/acre.

Layer 8-- Geosynthetic Clay Liner (GCL): The hydraulic conductivity of the GCL was set equal to 3×10^{-9} cm/s the HELP default value for a bentonite mat. This value is also approximately equal to the average of the values reported in the manufacturer's specifications. Sensitivity analysis previously conducted indicated that the net infiltration rate is not sensitive to the GCLs hydraulic conductivity.

For comparison purposes, the infiltration through EPA's RCRA guidance cap was simulated using the HELP model. A list of the material properties used for the RCRA guidance cap are presented in Table 3.

TABLE 3
PROPERTIES OF THE MATERIALS
USED FOR THE RCRA GUIDANCE CAP

Layer	Thickness (in)	Saturated Conductivity (cm/s)	Porosity	Field Capacity	Wilting Point
Top soil	24	9.35×10^{-4}	0.473	0.222	0. 105
Sand Transition Layer	12	0.01	.417	0.045	0.018
FML	0.04	2×10^{-12}	-	-	-
Clay Liner	24	1×10^{-7}	0.43	.367	0.28

4.3 Transpiration

A key component in the cap's water budget is transpiration which is the removal of water from the soil by transpiring plants. In the UNSAT-H model, the transpiration term is calculated in three steps. First, the potential evapotranspiration is partitioned into potential evaporation and potential transpiration. The transpiration potential is then distributed over the root zone in proportion to the relative root density at each depth. As described in the closure cap, the vegetative cover will consist of a mixture of native grasses. To provide vegetation compatible with the local climatic conditions, the mixture was developed through consultation with the Agricultural Research Center, College of Forestry, University of Idaho, Moscow, ID, and the Cooperative Extension System, University of Idaho at Pocatello. The maximum depth and plant biomass used in the model are 3.5 ft and 440 g/m^2, respectively. Fifty percent (50 %) of the cap's surface is assumed to be bare of plants. All these values are consistent with the proposed vegetation mixture. Finally, the actual transpiration as a function of depth and time is computed from the potential evapotranspiration and the soil's moisture content.

In the HELP model, the top soil was conservatively assumed to maintain a vegetative cover with a leaf area index, LAI =1, which corresponds to a "poor stand of grass. The evapotranspiration zone depth was assumed to be 24 inches which is consistent with the default HELP for the area of Pocatello.

4.4 Additional Assumptions

In addition to the input parameters and assumptions discussed in the Sections 4.1 through 4.3, the UNSAT-H model includes the following assumptions:

- No surface runoff is generated. This is a very conservative assumption because net infiltration will primarily be a result of extreme rainfall events. However, a significant portion of the precipitation falling during these events may develop into surface runoff.

- The capillary barrier is assumed to generate no lateral drainage. This means that any water that does not evaporate or is not taken by the plants will infiltration through the cap.

- To minimize the impact of the assumed initial moisture distribution in the simulated soil column all simulations were run for 600 years, out of which the last 500 years were used to estimate the average percolation through the cap. The effect of the assumed initial conditions is negligible after the first 100 years of simulation.

The following additional assumptions were incorporated in the HELP models for both the proposed and guidance caps:

- To maximize percolation rates, no surface runoff was allowed.

- Initial conditions were set to steady state conditions, as estimated by the HELP program.

- The drainage length of the cap was conservatively set to 400 ft.

5. MODEL RESULTS

The hydrologic performance of the proposed closure cap was evaluated based on the input data and assumptions described in the previous section. Figure 2 shows the estimated annual percolation rate at the bottom of the biointrusion layer and the bottom of the GCL for the simulated 600 years of precipitation data generated using the UNSAT-H/HELP approach described in Section 2. The long-term percolation through the bottom of the biointrusion layer is 0.05 in/yr. This rate was calculated using the UNSAT-H model for the capillary barrier. The long term average percolation through the bottom of the GCL, estimated with the HELP model for the secondary cap underneath the biointrusion barrier and based on the last 500 years of this simulation, is 8×10^{-6} in/yr. Figure 2 also shows that the maximum annual percolation through the bottom of the GCL is consistently less than 10^{-4} in/yr.

The performance of the proposed cap as well as the EPA RCRA guidance cap were also evaluated with the HELP model. A summary of all the of the different modeling simulations is

Figure 2: Estimated Annual Percolation Through the Proposed Cap

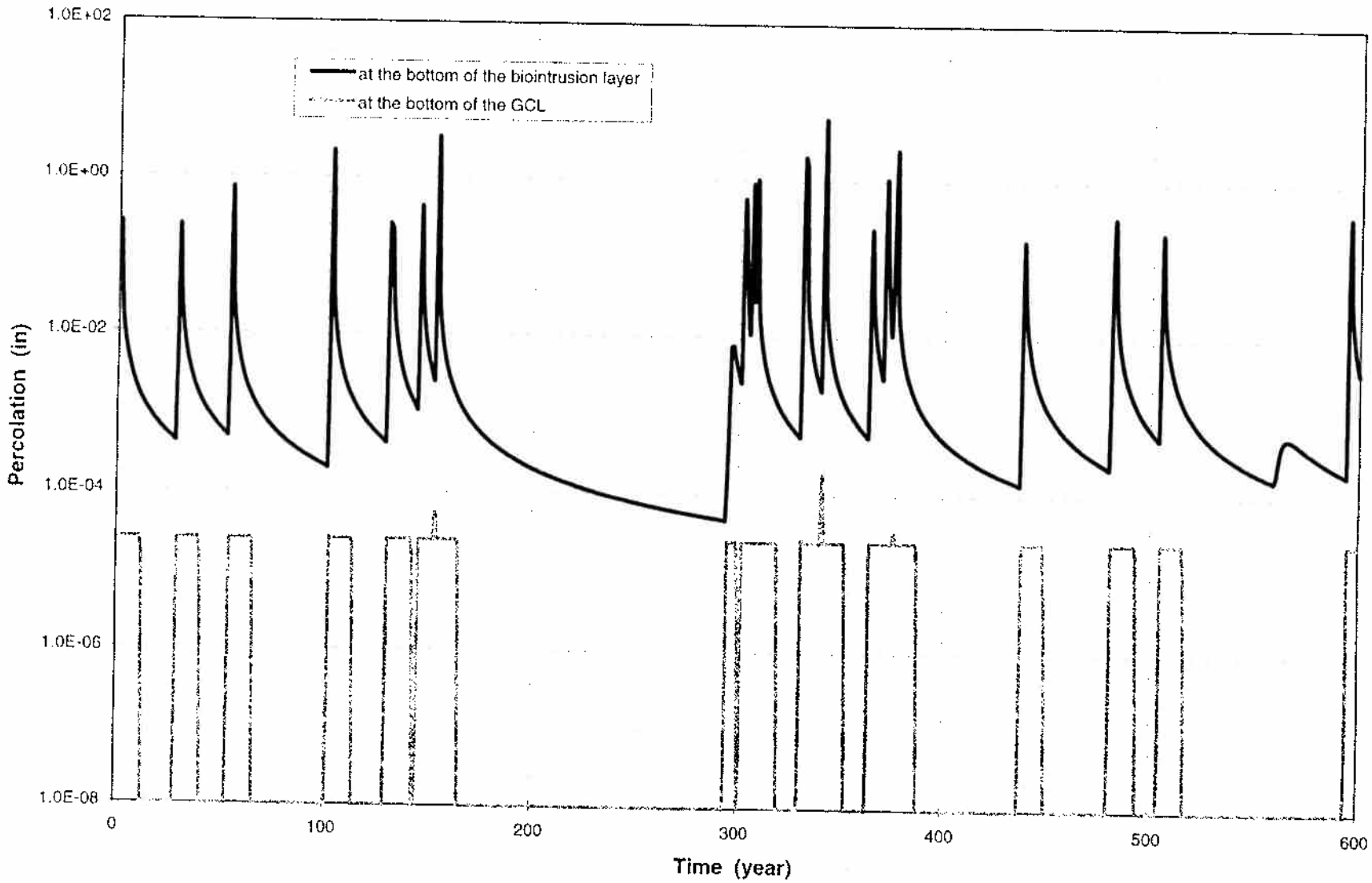

TABLE 4
MODELING RESULTS
FOR THE PROPOSED AND GUIDANCE CAPS

Cap	Modeling Approach	Runoff (in/yr)	Evapotranspiration (in/yr)	Lateral Drainage (in/yr)	Percolation (in/yr)
Proposed Cap[1]	UNSAT-H/HELP	-	11.62	0.05	3×10^{-6}
	HELP	-	6.98	4.69	2×10^{-5}
RCRA Guidance Cap[2]	HELP	-	11.23	.17	11×10^{-5}

[1] Simulated for 500 years

[2] Simulated for 44 years

presented in Table 4. These results show that for both of the modeling approaches, the net annual percolation through the proposed cap is lower than that predicted for the RCRA guidance cap. This indicates that the performance of the proposed cap exceeds that of the RCRA guidance cap.

6. SUMMARY

A numerical model was developed to evaluate the hydrological performance of the proposed cap and demonstrate its equivalency with the EPA's RCRA guidance cap. Two approaches were used to calculate the long-term water budget through the different layers of the proposed cap. The first approach is based on the combined application of two computer programs, UNSAT-H and HELP. The UNSAT-H program is used to simulate the movement of moisture through the capillary barrier, while the HELP program is used to simulate moisture movement through the secondary barrier underneath the capillary barrier. By combining these two computer programs, some of the limitations of each program are overcome. For comparison purposes, the proposed cap was also simulated in its entirety using the HELP program. To demonstrate the equivalency of the proposed cap to the guidance cap, the guidance cap was also modeled using the HELP program.

Based on available field data and data published in the literature for comparable materials, the water balance through the proposed and guidance caps was simulated for 500 years. The results of this modeling effort indicate that the net infiltration through the proposed cap is negligible (on the order of 10^{-5} to 10^{-6} in/yr). Furthermore, the performance of the proposed cap is expected to exceed the performance of the RCRA guidance cap.

7. LIST OF REFERENCES

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ATTACHMENT F-1

This attachment provides a list of the input and output files used in the UNSAT-H and HELP models described in Appendix F. All of the input/output files listed below are included in the attached computer diskettes at the end of this attachment.

HELP Model for Proposed Cap (8 Layers)

Because each HELP model (Version 3.03) is limited to 100 years, the long term performance of the cap was simulated by running five consecutive 100-years simulations. The moisture content at the end of each simulation was used as initial conditions in the following simulation. The input/output files are:

- Soil Properties and Initial Conditions (6 files, one for each 100 years of simulation)

  SOIL1.D10, SOIL2.D10, ... SOIL6.D10
- Precipitation (6 files, one for each 100 years of simulation)

  RAIN1.D4, RAIN2.D4, ... RAIN6.D4
- Temperature (6 files, one for each 100 years of simulation)

  TEMP1.D7, TEMP2.D7, ... TEMP6.D7
- Solar Radiation (6 files, one for each 100 years of simulation)

  RAD1.D13, RAD2.D13, ... RAD6.D13
- Evapotranspiration(1 file for 600 years of simulation)

  POCATEL.D11
- Output (6 files, one for each 100 years of simulation)

  Y100.OUT, Y200.OUT, ... Y600.OUT

HELP Model for EPA RCRA Guidance Cap

The RCRA Guidance cap was evaluated using the HELP model based on 44 years of recorded data between 1948 and 1991. The input/output files are:

- Soil Properties:

  RCRA.D10
- Precipitation (1 file for 44 years)

  POCATEL.D4
- Temperature (1 file for 44 years)

  POCATEL.D7
- Solar Radiation (1 file for 44 years)

  POCATEL.D13
- Evapotranspiration (1 file for 44 years)

  POCATEL.D11

- Output (1 file for 44 years)

  RCRA.OUT

UNSAT-H/HELP Model for the Proposed Cap

The proposed cap was also evaluated using a combined UNSAT-H/HELP model. The UNSAT-H was used to model moisture movement through the capillary barrier; the HELP model was used to model moisture through the secondary barrier underneath the biointrusion layer. The input/output files for the UNSAT-H model are

- Parameter input files (total of 600 files, one file for each year of simulation):

  Y001.INP, Y002.INP, ..., Y600.INP

- Input weather data files (total of 600 files, one file for each year of simulation):

  Y001.WEA, Y002.WEA, ..., Y600.WEA

  Files include daily precipitation, maximum and minimum temperatures, solar radiation, cloud cover, wind speed, etc.

- Output (total 600 files, one file for each year of simulation):

  Y001.INF, Y002.INF, ..., Y600.INF

  Files include computed daily fluxes at different depths for 600 years of simulation

The input/output files for the HELP model (4 layers) are:

- Soil Properties and Initial Conditions (6 files, one for each 100 years of simulation)

  SOIL1S.D10, SOIL2S.D10, ... SOIL6S.D10

- Precipitation (6 files, one for each 100 years of simulation- from UNSAT-H model)

  INF1.D4, INF2.D4, ... INF6.D4

- Temperature (average temperature from 44 years of record)

  TEMP.D7

- Solar Radiation (modified to reflect conditions below the biointrusion layer)

  RAD.D13

- Evapotranspiration (modified to reflect conditions below the biointrusion layer))

  EVAP.D11

- Output (6 files, one for each 100 years of simulation)

  Y1001S.OUT, Y200S.OUT, ... Y600S.OUT

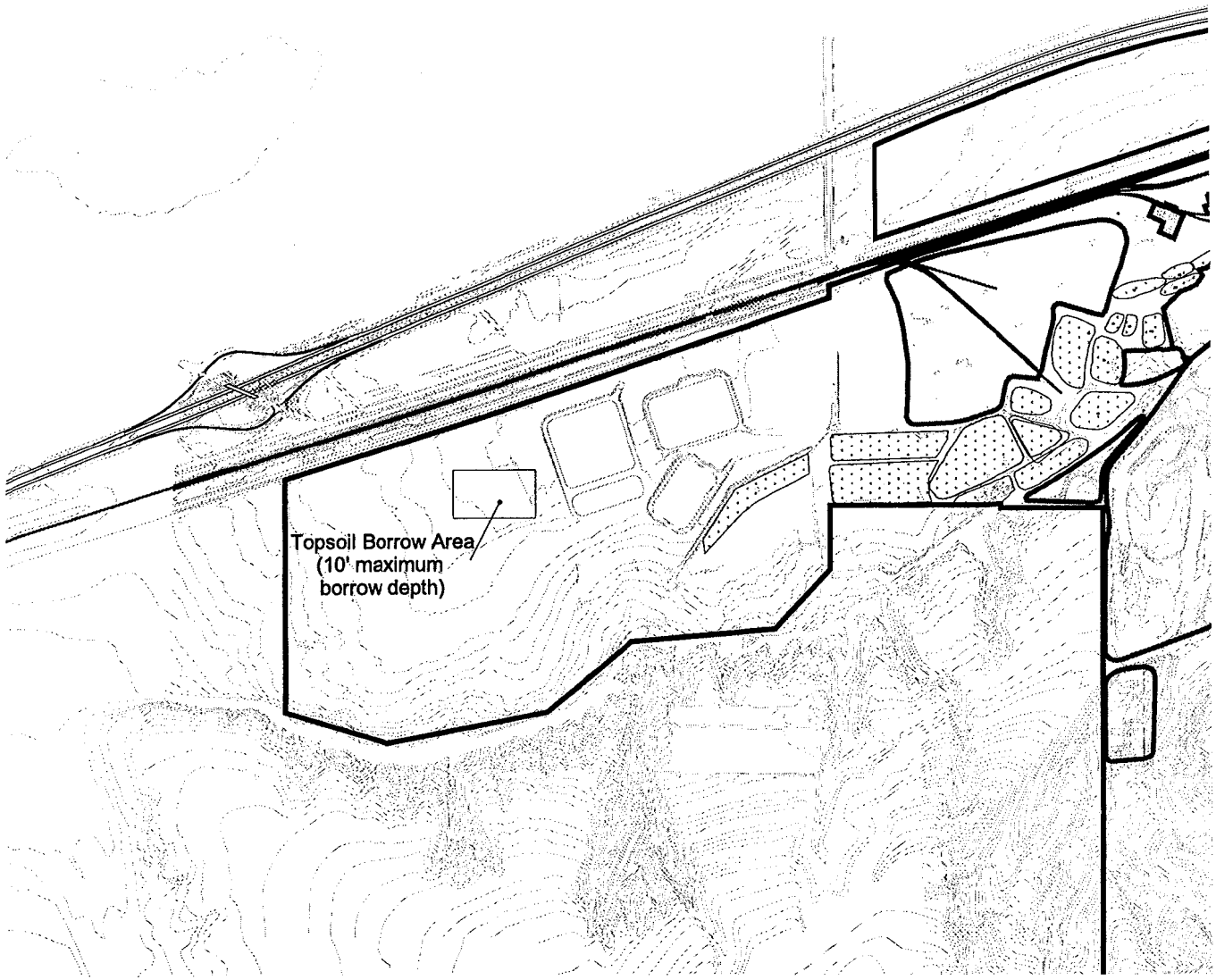
- Summary (yearly output from the UNSAT-H and HELP models)

  SUMMARY.XLS

Appendix B

Geotechnical Laboratory Results from the Cover/Cap Soil Borrow Area (Appendix D to the *Remedial Investigation Update Memorandum for the FMC Plant OU – June 2004*)

Figure A-D1
Borrow Area



FMC OU Boundaries
RU Boundaries
Highway
Railroads
Old Ponds
2ft_contours

N

0.7 0 0.7 Miles

Samples 18-1 through 18-6
Collected from Borrow Area
Shown

PERMEABILITY TEST RESULTS
ASTM D5084

Project: FMC Pond Closure
Client: A & E Engineering

Date: August 31,2001
File: AEENGR P01081A

Permeability Test Results
ASTM D5084

Sample ID.	Lab Number	Soil Description	Maximum Dry Density	Optimum Moisture	Initial % Remold	Final % Remold	Initial Density	Initial Moisture	Final Density	Final Moisture	Permeability Rate cm/sec	Inches per day
18-1	B1L1740	Silt	107.5 pcf	17.0%	80	93.2	85.6	17.4	100.1	25.3	7.5 E-05	2.54
18-1	B1L1740	Silt	107.5 pcf	17.0%	85	95.0	92.1	17.4	102.1	24.3	1.5 E-05	0.50
18-1	B1L1740a	Silt w/ *	111.0 pcf	16.5%	80	93.5	85.8	16.1	103.8	20.8	6.6 E-05	2.23
18-2	B1L1741	Silt	104.0 pcf	17.5%	80	92.1	83.4	17.5	95.7	27.5	3.3 E-05	1.10
18-2	B1L1741	Silt	104.0 pcf	17.5%	85	92.5	88.7	17.5	96.2	28.4	9.4 E-05	3.20
18-2	B1L1741a	Silt w/ *	110.0 pcf	16.5%	80	90.0	89.6	15.2	100.2	24.2	1.7 E-04	5.62
18-3	B1L1742	Calcitic Silt	97.5 pcf	21.5%	80	95.0	78.3	21.3	92.7	29.6	9.6 E-06	0.33
18-3	B1L1742	Calcitic Silt	97.5 pcf	21.5%	85	93.0	83.1	21.3	90.7	33.2	2.7 E-04	9.14
18-3	B1L1742a	Calcitic Silt w/ *	100.0 pcf	19.5%	80	93.9	86.5	18.0	95.8	25.1	4.5 E-04	15.47
18-4	B1L1743	Clayey Silt	100.5 pcf	20.5%	80	88.6	80.4	20.5	89.0	33.3	5.8 E-05	1.98
18-4	B1L1743	Clayey Silt	100.5 pcf	20.5%	85	89.6	84.9	20.5	90.1	35.1	9.3 E-05	3.15
18-4	B1L1743a	Clayey Silt w/ *	108.0 pcf	21.0%	80	87.9	82.7	21.5	90.5	33.2	3.8 E-05	1.29
18-5	B1L1744	Silt	105.5 pcf	16.0%	80	87.3	84.7	16.0	92.1	29.7	8.4 E-05	2.84
18-5	B1L1744	Silt	105.5 pcf	16.0%	85	89.9	89.7	16.0	94.8	29.8	9.1 E-05	3.10
18-5	B1L1744a	Silt w/ *	111.5 pcf	15.5%	80	89.2	89.5	15.5	99.5	29.1	6.9 E-05	2.33
18-6	B1L1745	Clayey Silt	108.5 pcf	16.0%	80	84.5	87.2	16.5	91.7	28.7	3.8 E-05	1.28
18-6	B1L1745	Clayey Silt	108.5 pcf	16.0%	85	90.3	92.5	16.5	97.9	28.9	8.1 E-05	2.76
18-6	B1L1745a	Clayey Silt w/ *	116.5 pcf	14.0%	80	86.5	90.7	14.2	99.9	25.6	6.2 E-05	2.09

* = 15% Pea Gravel

Note: Soils with loose densities tend to collapse at saturation causing an increase in density.
Classifications based on ASTM D422 (Hydrometer Analysis) and ASTM D2488 (Visual Classification)
All soils had varying amounts of calcium.

Reviewed by:

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-1

SAMPLE NO: B1L1740
DATE: 8-15-01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 107.5
OPTIMUM MOISTURE, %: 17.0

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 97%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.50	260.30	17.4	31.67	221.7	85.6	79.6%
Final	1.88	2.39	277.90	25.3	28.94	221.7	100.1	93.2%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
45.20	33.85	12.16	45.05	34.65	11.15	112	21	1.02E-04
45.05	34.65	11.15	44.80	36.50	8.90	349	23	8.10E-05
44.80	36.50	8.90	44.50	38.50	6.43	501	23	8.14E-05
48.80	42.00	7.29	48.50	43.50	5.36	509	23	7.58E-05
48.50	43.50	5.36	48.30	45.00	3.54	787	23	6.61E-05
48.30	45.00	3.54	48.20	45.60	2.79	395	23	7.56E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 7.5E-05
Maximum Gradient: 4.8
Minimum Gradient: 1.4

Final Density, pcf:(see note) 100.1
Final Moisture, pct: 25.3
Conductivity, in/day 2.5429

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-1

SAMPLE NO: B1L1740
DATE: 8-15-01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt w/15% Pea Gravel

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 111.0
OPTIMUM MOISTURE, %: 16.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	1 Ht, in	Dia, in	Wet Wt g	Moist Cont %	Area sq cm	Dry Wt g	Density pcf	Actual Remold %
Initial	1.99	2.49	266.00	16.5	31.42	228.3	89.8	80.9%
Final	1.90	2.37	286.00	25.3	28.46	228.3	103.8	93.5%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
44.50	31.00	14.47	44.30	33.00	12.11	365	22	6.44E-05
44.30	33.00	12.11	44.00	35.00	9.65	463	22	6.47E-05
44.00	35.00	9.65	43.70	36.70	7.50	528	22	6.30E-05
43.70	36.70	7.50	43.50	38.20	5.68	560	22	6.55E-05
48.50	38.20	11.04	48.10	40.40	8.25	561	22	6.86E-05
48.10	40.40	8.25	47.90	42.00	6.32	573	22	6.14E-05
47.90	42.00	6.32	47.70	43.10	4.93	489	22	6.71E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec:	6.6E-05	Final Density, pcf:	103.8
Maximum Gradient:	5.7	Final Moisture, pct:	25.3
Minimum Gradient:	2.5	Conductivity, in/day	2.23

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-1

SAMPLE NO: B1L1740
DATE: 8-15-01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt

STANDARD: ASTM D 698 REMOLD %: 85
MAXIMUM DRY DENSITY, PC 107.5
OPTIMUM MOISTURE, %: 17.0

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	3		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.00	2.49	276.50	17.4	31.42	235.5	92.1	85.7%
Final	1.91	2.42	292.80	24.3	29.67	235.5	102.1	95.0%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
12.70	7.70	7.24	12.20	8.20	5.73	788	20	1.61E-05
22.40	8.40	20.82	21.45	9.25	18.11	450	20	1.68E-05
21.45	9.25	18.11	20.80	9.90	16.15	406	20	1.53E-05
20.80	9.90	16.15	20.20	10.50	14.34	463	20	1.39E-05
20.20	10.50	14.34	19.50	11.20	12.22	578	20	1.50E-05
19.50	11.20	12.22	19.10	11.60	11.02	373	20	1.50E-05
19.10	11.60	11.02	18.50	12.20	9.20	650	20	1.50E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 1.5E-05
Maximum Gradient: 8.2
Minimum Gradient: 2.9

Final Density, pcf: 102.1
Final Moisture, pct: 24.3
Conductivity, in/day 0.5014

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-2

SAMPLE NO: B1L1741
DATE: 8/21/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt ML

STANDARD: ASTM D 698 REMOLD %: 85
MAXIMUM DRY DENSITY, PC 104.0
OPTIMUM MOISTURE, %: 17.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 95%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	267.70	17.5	31.42	227.8	88.7	85.3%
Final	1.93	2.44	292.50	28.4	30.17	227.8	96.2	92.5%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
44.00	32.70	12.11	43.60	35.00	9.22	350	22	9.86E-05
43.60	35.00	9.22	43.40	36.50	7.39	286	22	9.79E-05
47.90	36.50	12.22	47.50	39.00	9.11	369	22	1.01E-04
47.50	39.00	9.11	47.20	41.00	6.64	406	22	9.86E-05
49.80	41.00	9.43	49.60	43.00	7.07	391	22	9.32E-05
49.60	43.00	7.07	49.50	44.40	5.47	381	22	8.52E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 9.4E-05
Maximum Gradient: 4.8
Minimum Gradient: 2.8

Final Density, pcf: (see note) 96.2
Final Moisture, pct: 28.4
Conductivity, in/day 3.2117

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A & E Engineers
SAMPLE ID: 18-2

SAMPLE NO: B1L1741
DATE: 8/21/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt w/ 15% Pea Gravel

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 111.3
OPTIMUM MOISTURE, %: 15.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 95%

TEST DATA

Unit No =	1 Ht, in	Dia, in	Wet Wt g	Moist Cont %	Area sq cm	Dry Wt g	Density pcf	Actual Remold %
Initial	2.01	2.49	264.80	15.2	31.42	229.9	89.5	80.4%
Final	1.90	2.42	285.50	24.2	29.67	229.9	100.2	90.0%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
41.20	30.30	11.68	40.90	32.70	8.79	201	22	1.79E-04
40.90	32.70	8.79	40.60	34.50	6.54	214	22	1.75E-04
45.90	34.50	12.22	45.50	37.00	9.11	215	22	1.73E-04
45.50	37.00	9.11	45.20	39.00	6.64	238	22	1.68E-04
48.60	39.00	10.29	48.20	41.50	7.18	282	22	1.62E-04
48.20	41.50	7.18	48.00	43.00	5.36	234	22	1.58E-04
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 1.7E-04
Maximum Gradient: 4.8
Minimum Gradient: 2.8

Final Density, pcf: (see note) 100.2
Final Moisture, pct: 24.2
Conductivity, in/day 5.6212

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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FLEXWALL PERM ASTM D5084

PROJECT:	FMC Pond Closure	SAMPLE NO:	B1L1742
CLIENT:	A&E Engineering	DATE:	8/17/01
SAMPLE ID:	18-2	PROJ NO:	P01081A
		CLIENT NO:	AEENGR

SAMPLE DESCRIPTION: Silt

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 104.0
OPTIMUM MOISTURE, %: 17.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 96%

TEST DATA

Unit No =	1 Ht, in	Dia, in	Wet Wt g	Moist Cont %	Area sq cm	Dry Wt g	Density pcf	Actual Remold %
Initial	2.01	2.49	251.90	17.5	31.42	214.4	83.4	80.2%
Final	1.87	2.41	273.40	27.5	29.43	214.4	95.7	92.1%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
49.30	11.90	40.08	48.90	15.10	36.22	470	20	2.84E-05
48.80	15.40	35.80	48.40	18.25	32.31	340	20	3.98E-05
48.40	18.25	32.31	48.00	20.30	29.69	320	20	3.48E-05
48.00	20.30	29.69	47.80	22.30	27.33	350	20	3.12E-05
47.80	22.30	27.33	47.60	23.70	25.61	254	20	3.37E-05
47.60	23.70	25.61	47.30	25.80	23.04	430	20	3.24E-05
47.30	25.80	23.04	47.05	27.35	21.11	342	20	3.37E-05
47.05	27.35	21.11	47.00	28.00	20.36	153	20	3.12E-05
47.00	28.00	20.36	46.90	28.70	19.51	170	20	3.31E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec:	3.3E-05	Final Density, pcf:(see note)	95.7
Maximum Gradient:	15.8	Final Moisture, pct:	27.5
Minimum Gradient:	8.0	Conductivity, in/day	1.1090

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-3

SAMPLE NO: B1L1742
DATE: 9/4/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt w/calcium

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 97.5
OPTIMUM MOISTURE, %: 21.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.00	2.49	243.60	21.2	31.42	201.0	78.6	80.6%
Final	1.89	2.36	260.50	29.6	28.22	201.0	92.6	95.0%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
44.70	20.10	26.36	44.50	21.50	24.65	834	22	1.07E-05
44.50	21.50	24.65	44.40	22.20	23.79	458	22	1.03E-05
44.40	22.20	23.79	44.30	22.70	23.15	432	22	8.36E-06
44.30	22.70	23.15	44.20	23.40	22.29	533	22	9.41E-06
44.20	23.40	22.29	44.10	24.10	21.43	557	22	9.36E-06
44.10	24.10	21.43	44.00	24.80	20.58	556	22	9.64E-06
44.00	24.80	20.58	43.90	25.50	19.72	568	22	9.95E-06
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 9.6E-06
Maximum Gradient: 10.4
Minimum Gradient: 8.1

Final Density, pcf:(see note) 92.6
Final Moisture, pct: 29.6
Conductivity, in/day 0.33

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A & E Engineers
SAMPLE ID: 18-3

SAMPLE NO: B1L1742
DATE: 8/21/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Calcitic Silt w/15% Pea Gravel

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 106.5
OPTIMUM MOISTURE, %: 18.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	5		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	259.30	18.0	31.42	219.7	85.5	80.3%
Final	1.90	2.42	275.00	25.1	29.67	219.7	95.8	89.9%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
14.71	7.01	19.56	14.30	7.70	16.76	30	22	5.38E-04
14.30	7.70	16.76	13.81	8.30	14.00	35	22	5.37E-04
13.81	8.30	14.00	13.34	8.71	11.76	40	22	4.55E-04
13.34	8.71	11.76	12.93	9.28	9.27	45	22	5.52E-04
12.93	9.28	9.27	12.56	9.69	7.29	50	22	5.02E-04
12.56	9.69	7.29	12.19	10.11	5.28	75	22	4.49E-04
12.19	10.11	5.28	11.98	10.32	4.22	55	22	4.26E-04
11.98	10.32	4.22	11.81	10.50	3.33	50	22	4.95E-04
11.81	10.50	3.33	11.61	10.70	2.31	85	22	4.50E-04
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 4.5E-04
Maximum Gradient: 7.7
Minimum Gradient: 1.3

Final Density, pcf: (see note) 95.8
Final Moisture, pct: 25.1
Conductivity, in/day 15.47

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT:	FMC Pond Closure	SAMPLE NO:	B1L1742
CLIENT:	A&E Engineering	DATE:	8/22/01
SAMPLE ID:	18-3	PROJ NO:	P01081A
		CLIENT NO:	AEENGR

SAMPLE DESCRIPTION: Calcitic Silt

STANDARD: ASTM D 698 REMOLD %: 85
MAXIMUM DRY DENSITY, PC 97.5
OPTIMUM MOISTURE, %: 21.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	2		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	258.90	21.3	31.42	213.4	83.1	85.2%
Final	1.95	2.42	284.30	33.2	29.67	213.4	90.7	93.0%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
11.65	6.00	6.06	11.40	6.60	5.14	60	21	3.65E-04
11.40	6.60	5.14	11.02	7.08	4.22	90	21	2.92E-04
11.02	7.08	4.22	10.73	7.35	3.62	70	21	2.92E-04
10.73	7.35	3.62	10.22	7.91	2.48	220	21	2.29E-04
10.22	7.91	2.48	10.01	8.11	2.04	90	21	2.89E-04
10.01	8.11	2.04	9.90	8.21	1.81	60	21	2.65E-04
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec:	2.7E-04	Final Density, pcf:(see note)	90.7
Maximum Gradient:	2.4	Final Moisture, pct:	33.2
Minimum Gradient:	0.8	Conductivity, in/day	9.14

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-4

SAMPLE NO: B1L1743
DATE: 8/15/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Clayey Silt w/15% Pea Gravel ML/CL

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 103.0
OPTIMUM MOISTURE, %: 21.0

CHMBR PRES 10 psi
BACK PRESS: 9 psi
PCT SATURAT 99%

TEST DATA

Unit No =	5		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	257.67	21.3	31.42	212.4	82.7	80.3%
Final	1.96	2.41	283.00	33.2	29.43	212.4	90.5	87.9%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
13.55	3.35	25.91	12.85	4.30	21.72	240	20	8.38E-05
10.00	4.57	13.79	9.41	5.21	10.67	571	20	5.12E-05
9.41	5.21	10.67	8.50	6.15	5.97	1451	20	4.56E-05
8.50	6.15	5.97	8.28	6.40	4.78	600	20	4.23E-05
8.28	6.40	4.78	8.17	6.53	4.17	542	20	2.87E-05
8.17	6.53	4.17	7.94	6.74	3.05	1010	20	3.53E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	20	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	20	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 3.8E-05
Maximum Gradient: 10.2
Minimum Gradient: 1.6

Final Density, pcf: (see note) 90.5
Final Moisture, pct: 33.2
Conductivity, in/day 1.29

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT:	FMC Pond Closure	SAMPLE NO:	B1L1743
CLIENT:	A&E Engineering	DATE:	8/15/01
SAMPLE ID:	18-4	PROJ NO:	P01081A
		CLIENT NO:	AEENGR

SAMPLE DESCRIPTION: Clayey Silt ML/CL

STANDARD: ASTM D 698 REMOLD %: 85
MAXIMUM DRY DENSITY, PC 100.5
OPTIMUM MOISTURE, %: 20.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 98%

TEST DATA

Unit No =	4		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.02	2.49	264.30	20.5	31.42	219.3	84.9	84.5%
Final	2.00	2.43	296.40	35.1	29.92	219.3	90.1	89.6%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
18.10	8.30	14.79	17.30	9.20	12.22	120	20	8.95E-05
17.30	9.20	12.22	15.60	10.90	7.09	360	20	8.51E-05
15.60	10.90	7.09	15.05	11.45	5.43	180	20	8.34E-05
15.05	11.45	5.43	14.30	12.20	3.17	368	20	8.23E-05
22.70	12.20	15.84	21.90	12.90	13.58	90	20	9.62E-05
21.90	12.90	13.58	21.20	13.60	11.47	96	20	9.90E-05
21.20	13.60	11.47	20.20	14.60	8.45	201	20	8.55E-05
20.20	14.60	8.45	19.60	15.20	6.64	151	20	8.98E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec:	9.3E-05	Final Density, pcf: (see note)	90.1
Maximum Gradient:	6.2	Final Moisture, pct:	35.1
Minimum Gradient:	2.1	Conductivity, in/day	3.15

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT:	FMC Pond Closure	SAMPLE NO:	B1L1744
CLIENT:	A&E Engineering	DATE:	8/23/01
SAMPLE ID:	18-5	PROJ NO:	P01081A
		CLIENT NO:	AEENGR

SAMPLE DESCRIPTION: Silt ML

STANDARD: ASTM D 698 REMOLD %: 85

MAXIMUM DRY DENSITY, PC 105.5

OPTIMUM MOISTURE, %: 16.0

CHMBR PRES 20 psi

BACK PRESS: 19 psi

PCT SATURAT 98%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	267.28	16.0	31.42	230.4	89.7	85.0%
Final	1.98	2.44	299.10	29.8	30.17	230.4	94.8	89.9%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
45.10	31.00	15.11	45.00	31.70	14.25	86	21.5	9.06E-05
45.00	31.70	14.25	44.90	32.40	13.40	86	21.5	9.51E-05
44.90	32.40	13.40	44.80	33.10	12.54	90	21.5	9.80E-05
44.80	33.10	12.54	44.70	33.80	11.68	102	21.5	9.26E-05
44.70	33.80	11.68	44.60	34.60	10.72	124	21.5	9.19E-05
44.60	34.60	10.72	44.50	35.30	9.86	126	20.5	9.04E-05
44.50	35.30	9.86	44.40	36.00	9.00	139	20.5	8.94E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec:	9.1E-05	Final Density, pcf: (see note)	94.8
Maximum Gradient:	5.9	Final Moisture, pct:	29.8
Minimum Gradient:	3.9	Conductivity, in/day	3.10

Average based on last 4 readings within 25% of mean.

Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-4

SAMPLE NO: B1L1743
DATE: 8/15/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Clayey Silt ML/CL

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 100.5
OPTIMUM MOISTURE, %: 20.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.00	2.50	249.70	20.5	31.67	207.2	80.4	80.0%
Final	1.96	2.40	276.30	33.3	29.19	207.2	89.0	88.6%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
41.80	30.55	12.06	41.60	31.90	10.40	296	21	6.80E-05
41.60	30.90	11.47	41.30	33.20	8.68	637	23	5.68E-05
41.30	33.20	8.68	41.00	35.00	6.43	602	23	6.47E-05
41.00	35.00	6.43	40.80	36.40	4.72	679	23	5.91E-05
48.40	38.50	10.61	48.00	40.60	7.93	615	23	6.14E-05
48.00	40.60	7.93	47.70	42.50	5.57	819	23	5.60E-05
47.70	42.50	5.57	47.50	43.80	3.97	783	23	5.61E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 5.8E-05
Maximum Gradient: 4.7
Minimum Gradient: 2.2

Final Density, pcf: (see note) 89.0
Final Moisture, pct: 33.3
Conductivity, in/day 1.98

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-5

SAMPLE NO: B1L1744
DATE: 8/22/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt ML

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 105.5
OPTIMUM MOISTURE, %: 16.0

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 96%

TEST DATA

Unit No =	2		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	252.30	16.0	31.42	217.5	84.7	80.2%
Final	1.94	2.43	282.00	29.7	29.92	217.5	92.1	87.3%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
39.70	16.30	25.08	39.60	17.10	24.11	60	21	8.63E-05
39.60	17.10	24.11	39.50	17.80	23.26	63	21	7.48E-05
39.50	17.80	23.26	39.40	18.60	22.29	63	21	8.88E-05
39.40	18.60	22.29	39.30	19.30	21.43	61	21	8.47E-05
39.30	19.30	21.43	39.20	20.00	20.58	68	21	7.82E-05
39.20	20.00	20.58	39.10	20.70	19.72	68	21	8.24E-05
39.10	20.70	19.72	39.00	21.60	18.65	88	21	8.32E-05
39.00	21.60	18.65	38.90	22.10	18.01	53	21	8.65E-05
38.90	22.10	18.01	38.80	22.80	17.15	78	21	8.24E-05
38.80	22.80	17.15	38.70	23.50	16.29	82	21	8.24E-05

Average K, cm/sec: 8.4E-05
Maximum Gradient: 9.9
Minimum Gradient: 6.8

Final Density, pcf: (see note) 92.1
Final Moisture, pct: 29.7
Conductivity, in/day 2.84

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-5

SAMPLE NO: B1L1744
DATE: 8/23/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Silt w/15% Pea Gravel

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 111.5
OPTIMUM MOISTURE, %: 13.5

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 99%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	260.90	13.5	31.42	229.9	89.5	80.2%
Final	1.93	2.41	296.80	29.1	29.43	229.9	99.5	89.2%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
45.60	22.50	24.76	45.50	23.20	23.90	78	21.5	6.02E-05
45.50	23.20	23.90	45.40	24.00	22.94	71	21.5	7.67E-05
45.40	24.00	22.94	45.30	24.70	22.08	78	21.5	6.51E-05
45.30	24.70	22.08	45.20	25.40	21.22	77	21.5	6.85E-05
45.20	25.40	21.22	45.10	26.10	20.36	77	21.5	7.14E-05
45.10	26.10	20.36	45.00	26.90	19.40	92	21	6.97E-05
45.00	26.90	19.40	44.90	27.60	18.54	95	20.5	6.50E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec:	6.9E-05	Final Density, pcf:(see note)	99.5
Maximum Gradient:	9.7	Final Moisture, pct:	29.1
Minimum Gradient:	7.6	Conductivity, in/day	2.33

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-6

SAMPLE NO: B1L1745
DATE: 8/23/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Clayey Silt

STANDARD: ASTM D 698 REMOLD %: 85
MAXIMUM DRY DENSITY, PC 108.5
OPTIMUM MOISTURE, %: 16.0

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 97%

TEST DATA

Unit No =	2		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	2.01	2.49	276.90	16.5	31.42	237.7	92.5	85.3%
Final	2.01	2.42	306.30	28.9	29.67	237.7	97.9	90.3%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
47.50	32.00	16.61	47.40	32.70	15.75	88	21	8.29E-05
47.40	32.70	15.75	47.30	33.40	14.90	94	21	8.10E-05
47.30	33.40	14.90	47.20	34.10	14.04	99	21	8.24E-05
47.20	34.10	14.04	47.10	34.90	13.08	118	21	8.23E-05
47.10	34.90	13.08	47.00	35.60	12.22	115	21	8.11E-05
47.00	35.60	12.22	46.90	36.30	11.36	128	21	7.82E-05
46.90	36.30	11.36	46.80	37.00	10.50	130	21	8.31E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 8.1E-05
Maximum Gradient: 6.5
Minimum Gradient: 4.5

Final Density, pcf:(see note) 97.9
Final Moisture, pct: 28.9
Conductivity, in/day 2.76

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-6

SAMPLE NO: B1L1745
DATE: 8/23/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Clayey Silt

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 108.5
OPTIMUM MOISTURE, %: 16.0

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT. 99%

TEST DATA

Unit No =	1		Wet Wt	Moist	Area	Dry Wt	Density	Actual Remold
	Ht, in	Dia, in	g	Cont %	sq cm	g	pcf	%
Initial	1.99	2.49	258.27	16.5	31.42	221.7	87.2	80.3%
Final	1.97	2.44	285.40	28.7	30.17	221.7	91.7	84.5%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
45.10	22.30	24.44	45.00	23.00	23.58	120	21	3.95E-05
45.00	23.00	23.58	44.90	23.70	22.72	127	21	3.87E-05
44.90	23.70	22.72	44.80	24.60	21.65	170	21	3.75E-05
44.80	24.60	21.65	44.70	25.20	20.90	123	21	3.79E-05
44.70	25.20	20.90	44.60	25.80	20.15	118	21	4.10E-05
44.60	25.80	20.15	44.50	26.50	19.29	154	21	3.75E-05
44.50	26.50	19.29	44.40	27.20	18.43	167	21	3.61E-05
44.40	27.20	18.43	44.30	27.90	17.58	172	21	3.63E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 3.8E-05
Maximum Gradient: 9.6
Minimum Gradient: 7.3

Final Density, pcf:(see note) 91.7
Final Moisture, pct: 28.7
Conductivity, in/day 1.28

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

Reviewed by:

Strata Engineering & Testing

FLEXWALL PERM ASTM D5084

PROJECT: FMC Pond Closure
CLIENT: A&E Engineering
SAMPLE ID: 18-6

SAMPLE NO: B1L1745
DATE: 8/23/01
PROJ NO: P01081A
CLIENT NO: AEENGR

SAMPLE DESCRIPTION: Clayey Silt w/15% Pea Gravel

STANDARD: ASTM D 698 REMOLD %: 80
MAXIMUM DRY DENSITY, PC 115.5
OPTIMUM MOISTURE, %: 14.0

CHMBR PRES 20 psi
BACK PRESS: 19 psi
PCT SATURAT 97%

TEST DATA

Unit No =	1 Ht, in	Dia, in	Wet Wt g	Moist Cont %	Area sq cm	Dry Wt g	Density pcf	Actual Remold %
Initial	2.02	2.49	270.40	14.2	31.42	236.8	91.7	79.4%
Final	1.98	2.41	297.30	25.6	29.43	236.8	99.9	86.5%

START H2	H1	delta 1	STOP H2	H1	delta 2	T sec	Temp Tx	K cm/s
48.20	33.70	15.54	47.70	36.20	12.32	473	21	6.69E-05
47.70	36.20	12.32	47.40	38.50	9.54	567	21	6.15E-05
47.40	38.50	9.54	47.10	40.10	7.50	511	21	6.42E-05
47.10	40.10	7.50	46.90	41.60	5.68	574	21	6.60E-05
48.80	41.60	7.72	48.50	43.70	5.14	1013	21	5.47E-05
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00
0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00E+00

Average K, cm/sec: 6.2E-05
Maximum Gradient: 6.1
Minimum Gradient: 3.0

Final Density, pcf:(see note) 99.9
Final Moisture, pct: 25.6
Conductivity, in/day 2.09

Average based on last 4 readings within 25% of mean.
Note: Samples with loose densities tend to collapse at saturation causing an increase in density.

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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

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MOISTURE-DENSITY RELATIONSHIP
ASTM D 698
METHOD A/METHOD B

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

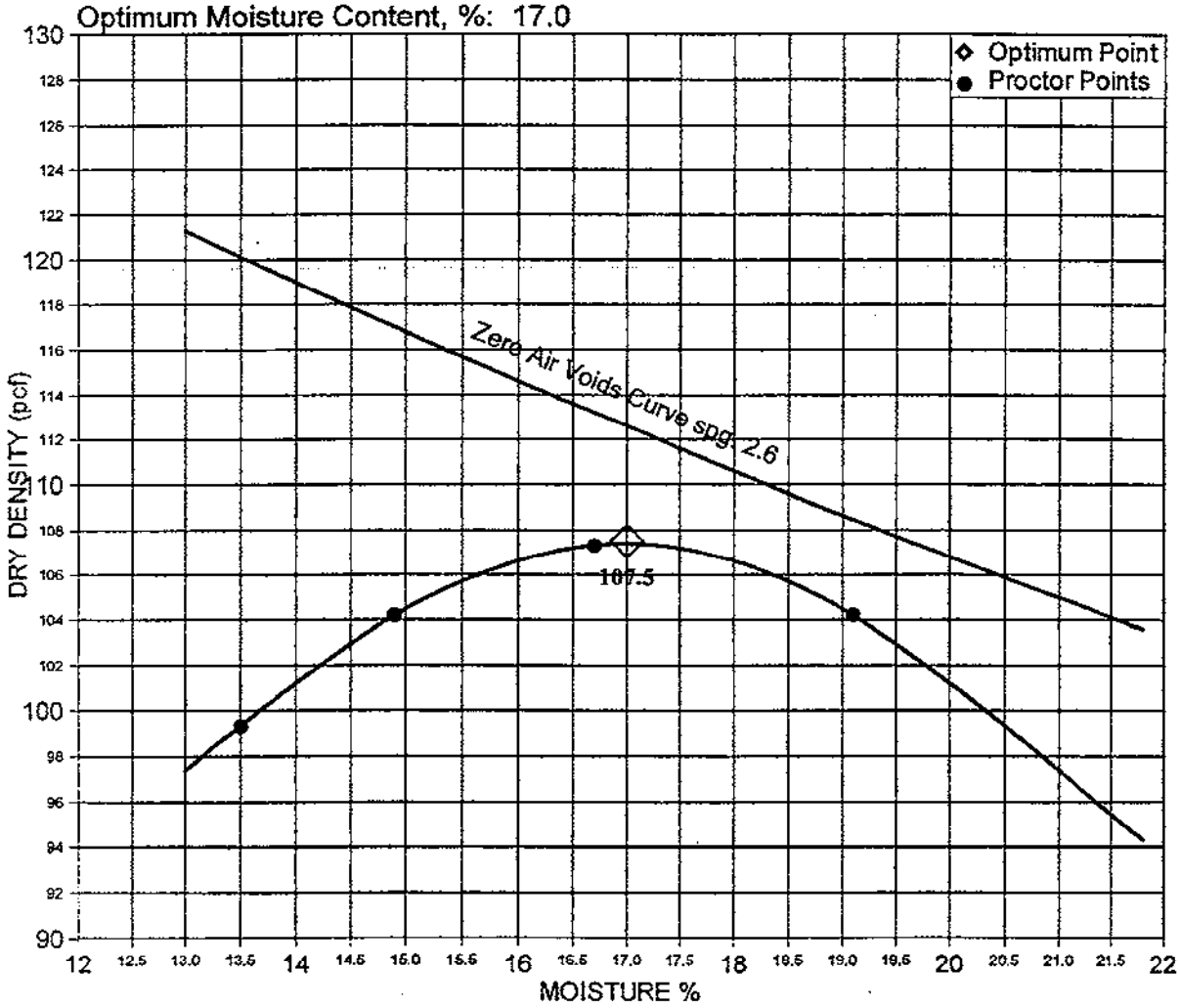
Method A

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/9/01
Tested By: CV - Strata
Sample Number: B1L1740
Sample Location: Test Hole 18-1
Sample Description: Silt
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch		
#4 screen	100	100

Maximum Dry Density, pcf : 107.5
Optimum Moisture Content, %: 17.0



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

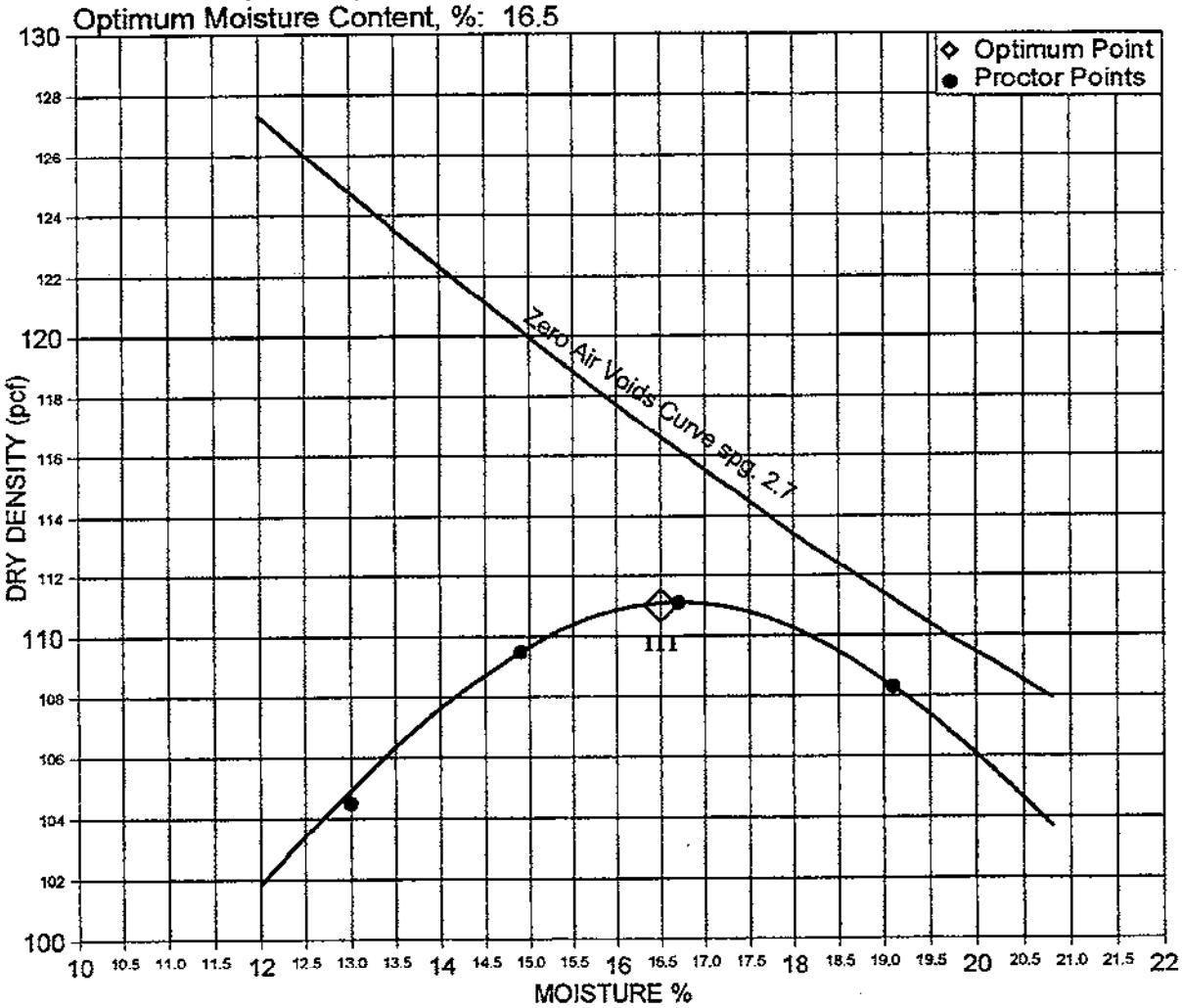
Method B

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/10/01
Tested By: CV - Strata
Sample Number: B1L1740A
Sample Location: Test Hole 18-1
Sample Description: Silt w/15% Pea Gravel
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch	100	100
#4 screen		

Maximum Dry Density, pcf : 111.0
Optimum Moisture Content, %: 16.5



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STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

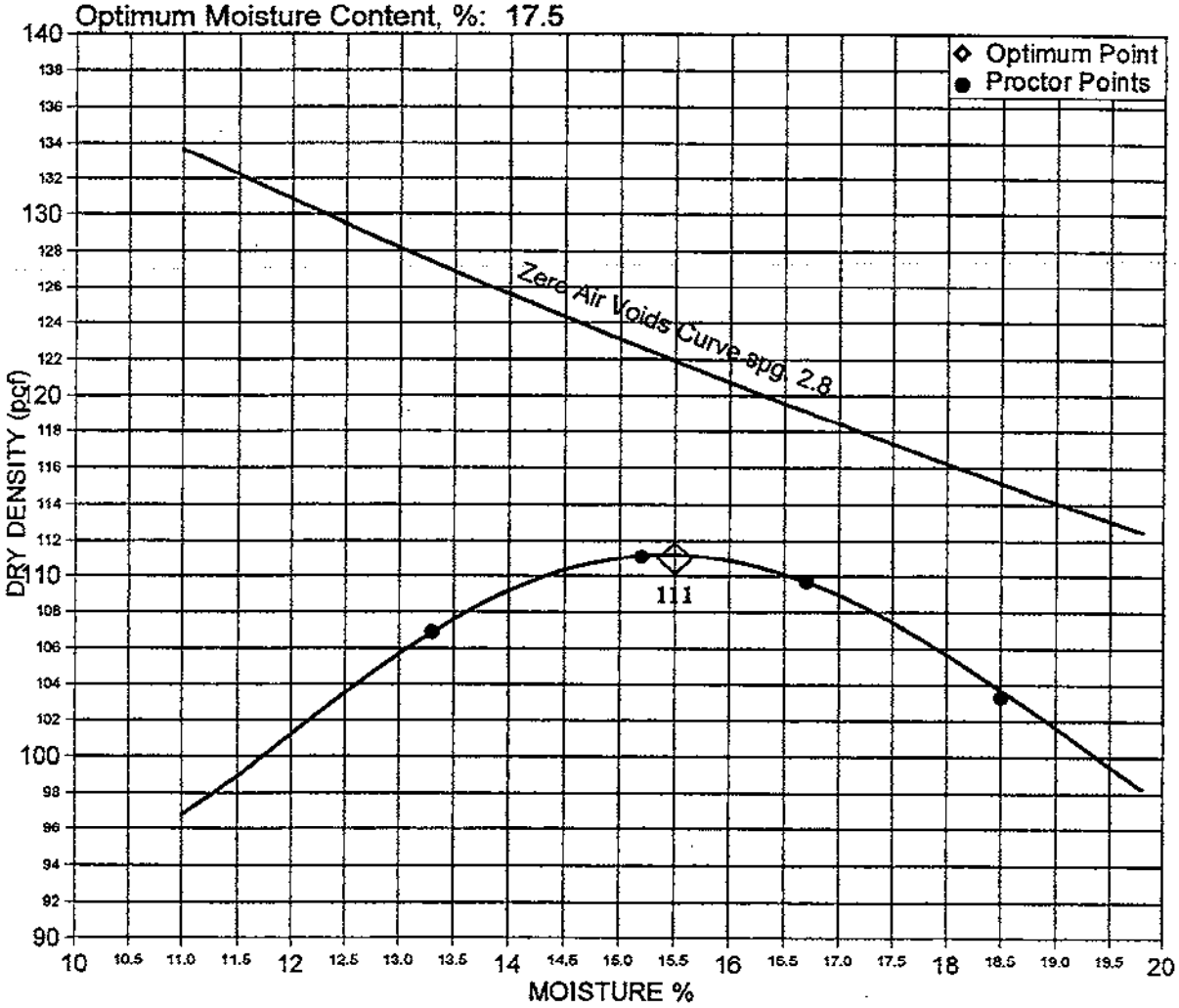
Method A

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/9/01
Tested By: JD - Strata
Sample Number: B1L1741
Sample Location: 18-2
Sample Description: Silt
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch		
#4 screen	100	100

Maximum Dry Density, pcf : 104.0
Optimum Moisture Content, %: 17.5



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

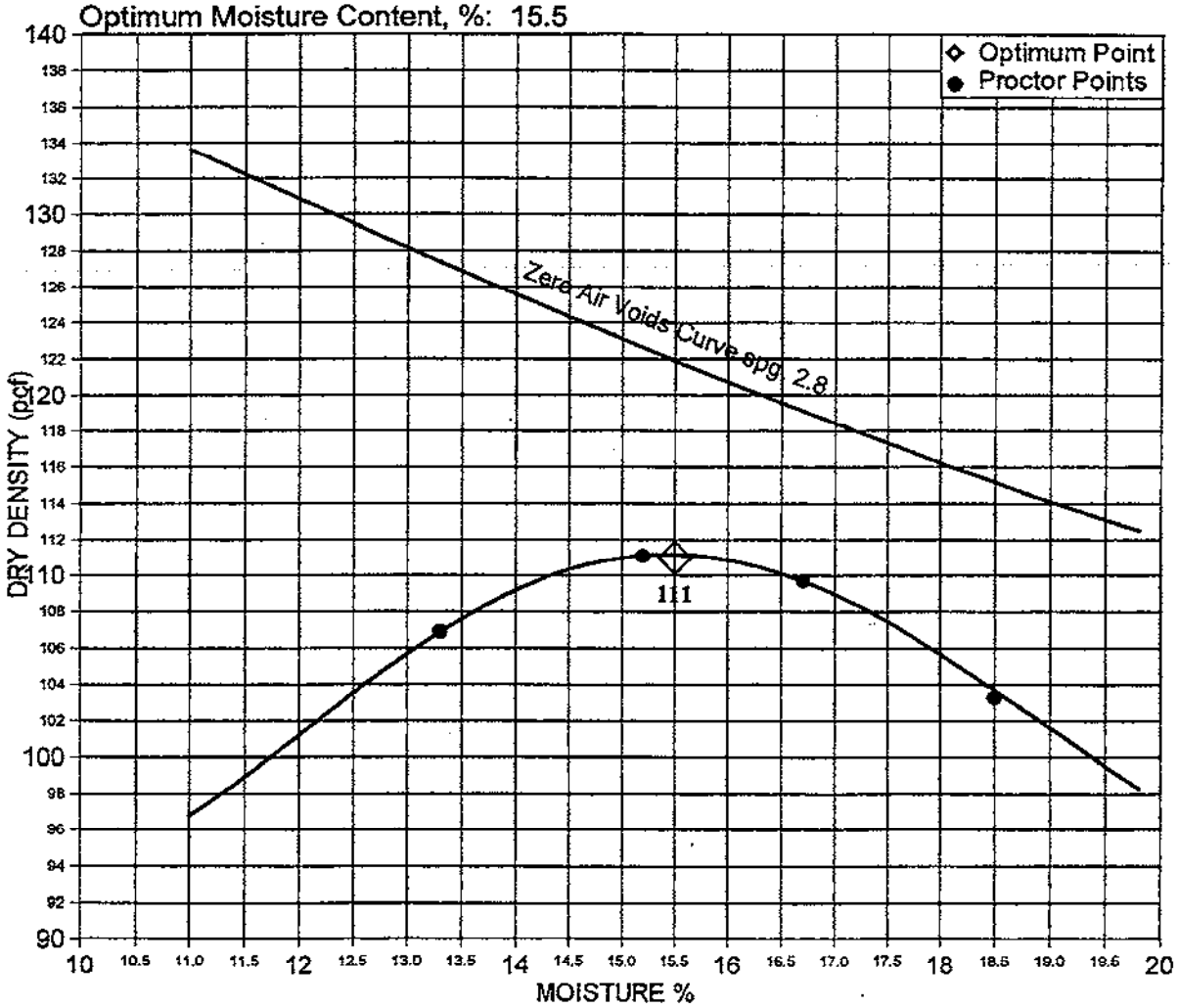
Method B

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/10/01
Tested By: JD - Strata
Sample Number: B1L1741A
Sample Location: 18-2
Sample Description: Silt w/15% Pea Gravel
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch	100	100
#4 screen		

Maximum Dry Density, pcf : 111.0
Optimum Moisture Content, %: 15.5



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STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

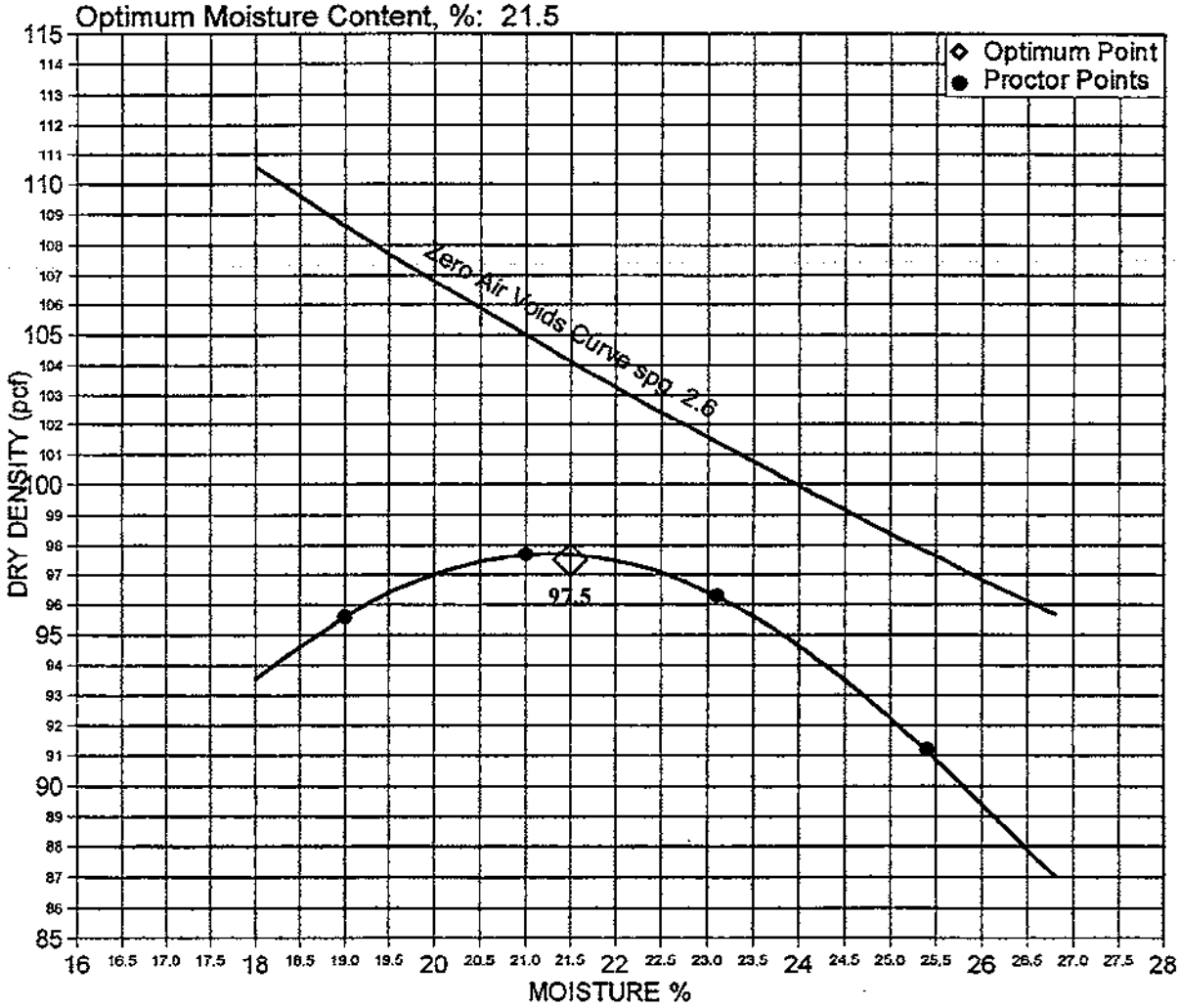
Method A

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/9/01
Tested By: CV - Strata
Sample Number: B1L1742
Sample Location: 18-3
Sample Description: Calcitic Silt
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch		
#4 screen	100	100

Maximum Dry Density, pcf : 97.5
Optimum Moisture Content, %: 21.5



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STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

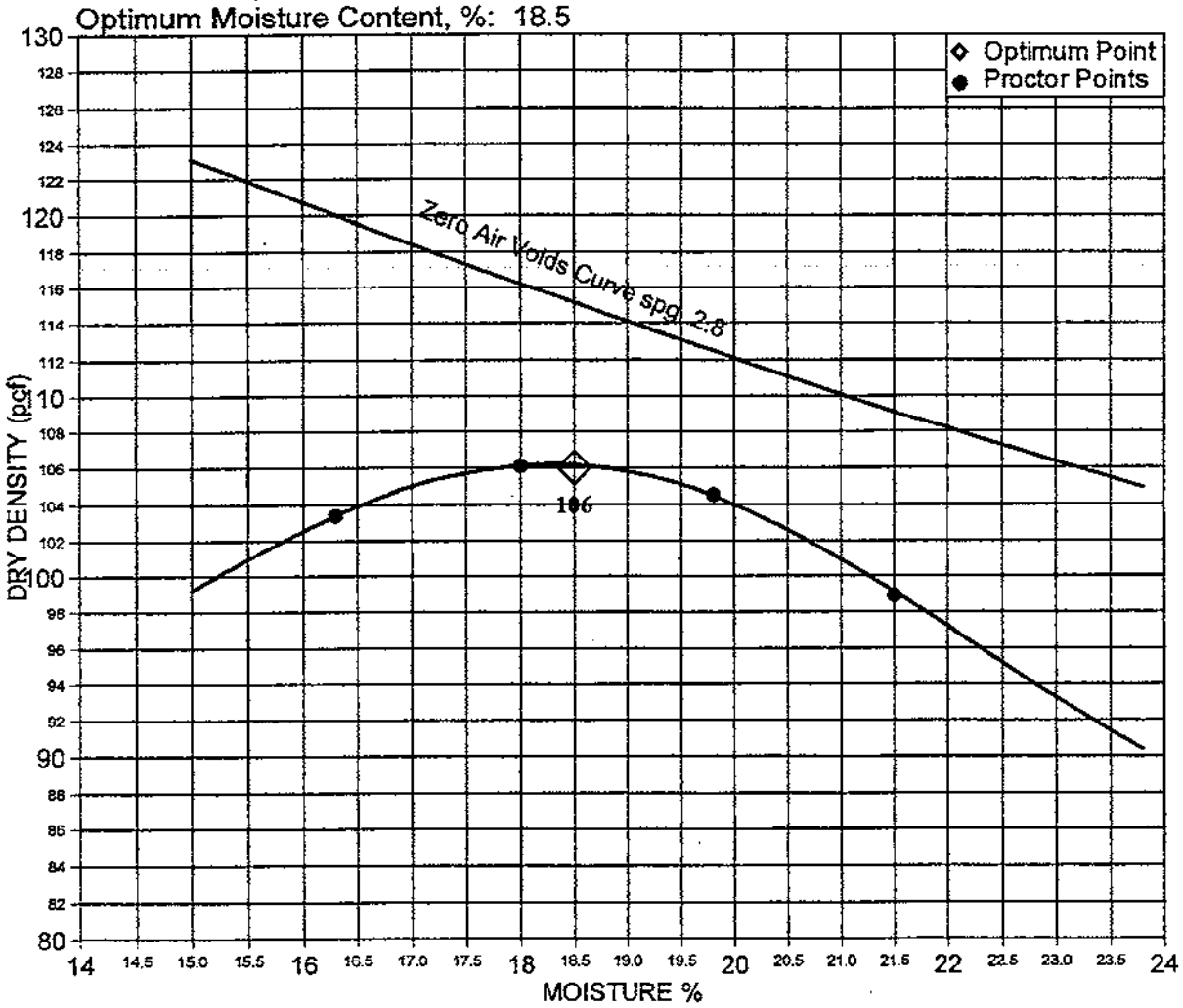
Method B

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/10/01
Tested By: CV - Strata
Sample Number: B1L1742A
Sample Location: 18-3
Sample Description: Calcitic Silt w/15% Pea Gravel
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch	100	100
#4 screen		

Maximum Dry Density, pcf : 106.0
Optimum Moisture Content, %: 18.5



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

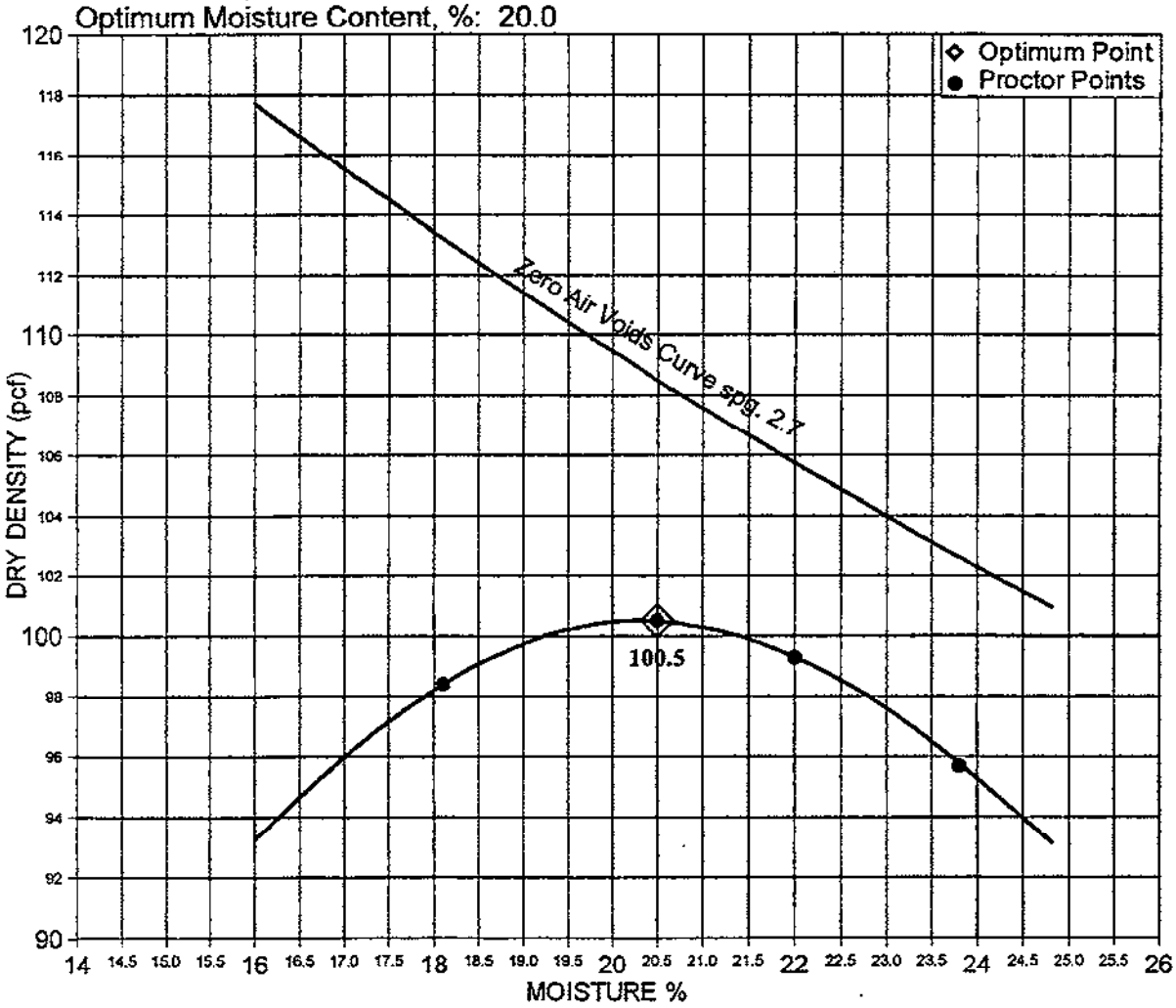
Method A

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/9/01
Tested By: CV - Strata
Sample Number: B1L1743
Sample Location: Test Hole 18-4
Sample Description: Clayey Silt
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch		
#4 screen	100	100

Maximum Dry Density, pcf : 100.5
Optimum Moisture Content, %: 20.0



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

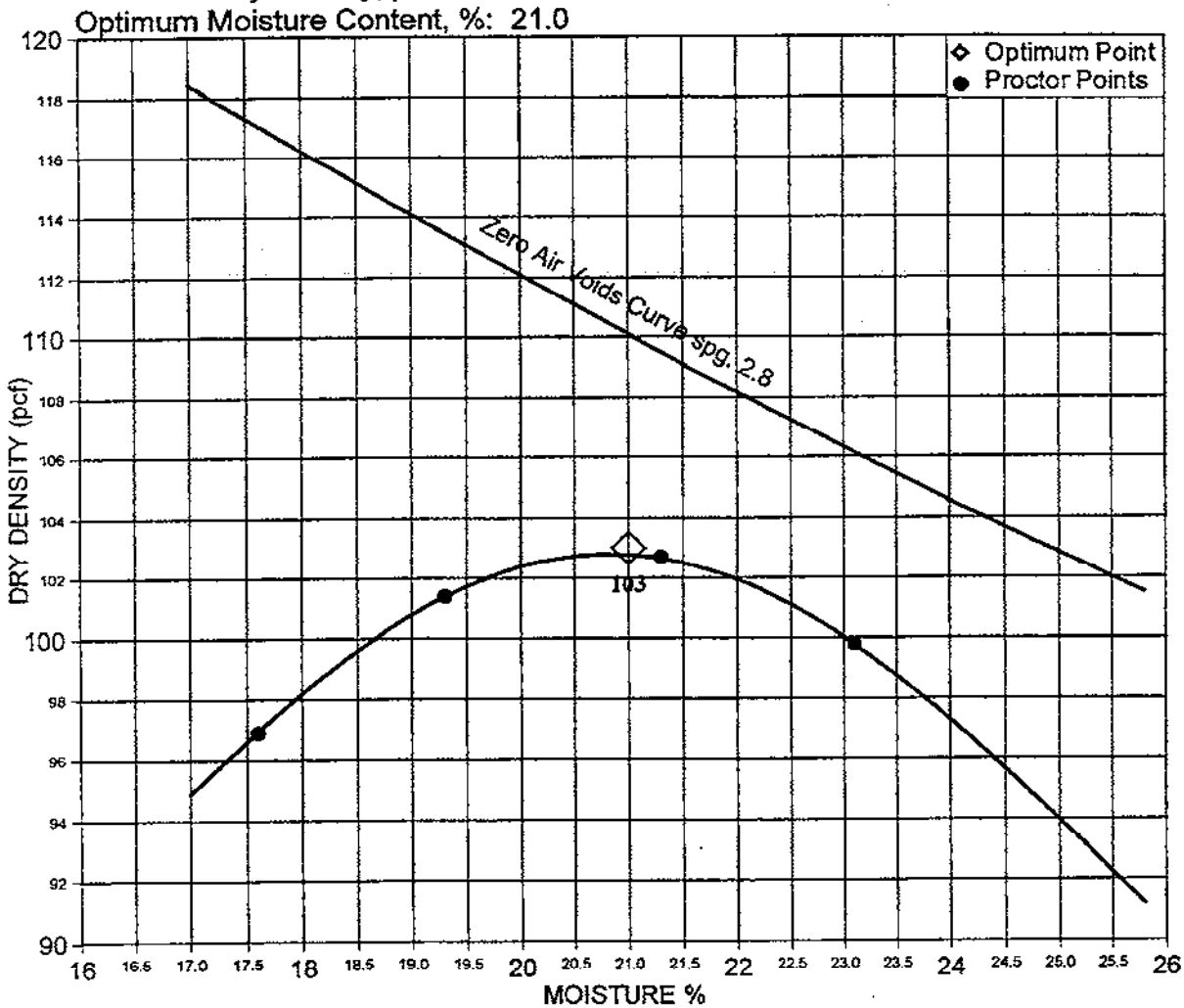
Method B

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/10/01
Tested By: CV - Strata
Sample Number: B1L1743A
Sample Location: Test Hole 18-4
Sample Description: Clayey Silt w/15% Pea Gravel
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch	100	100
#4 screen		

Maximum Dry Density, pcf : 103.0
Optimum Moisture Content, %: 21.0



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

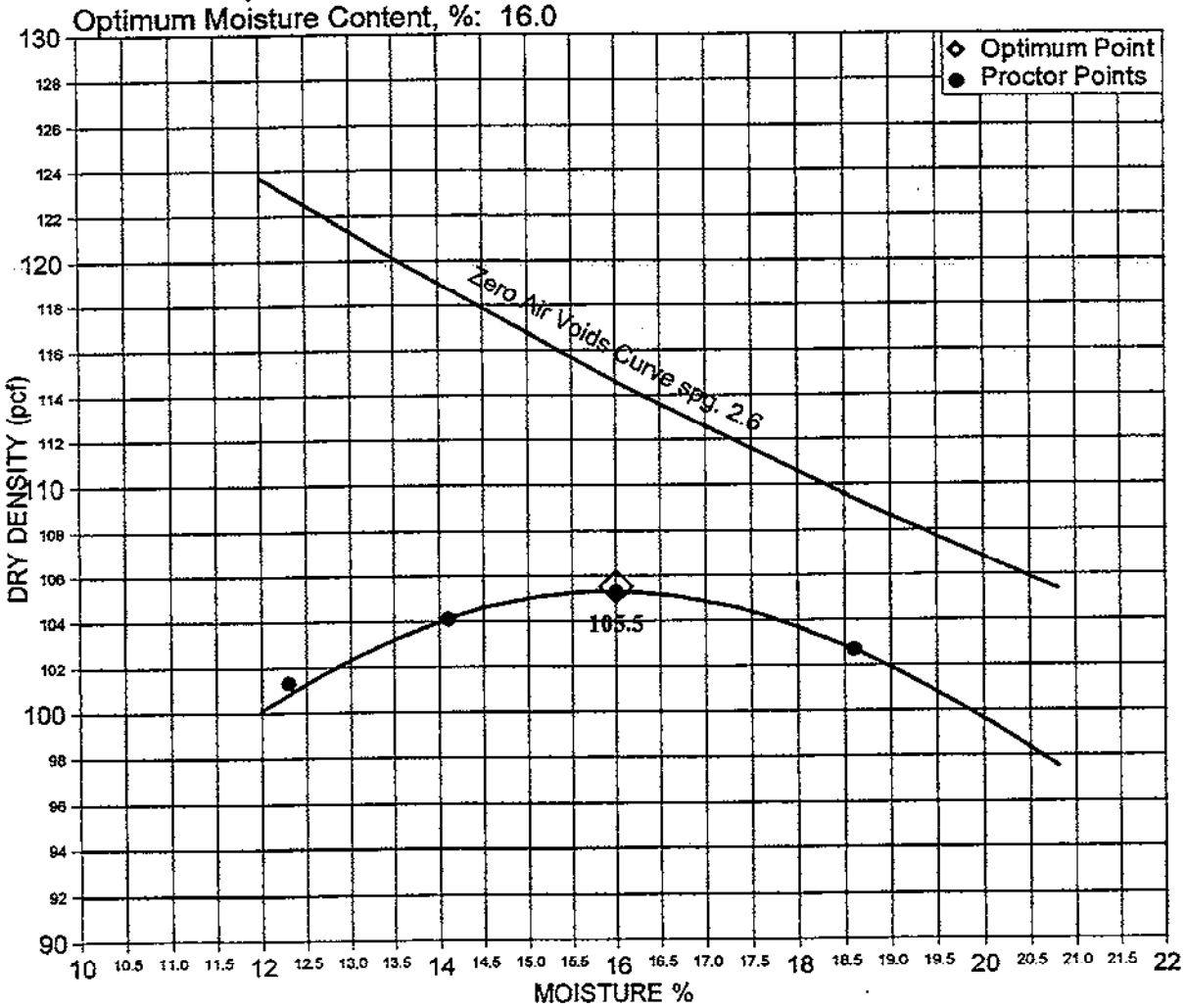
Method A

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/9/01
Tested By: JD - Strata
Sample Number: B1L1744
Sample Location: 18-5
Sample Description: Silt
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch		
#4 screen	100	100

Maximum Dry Density, pcf : 105.5
Optimum Moisture Content, %: 16.0



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

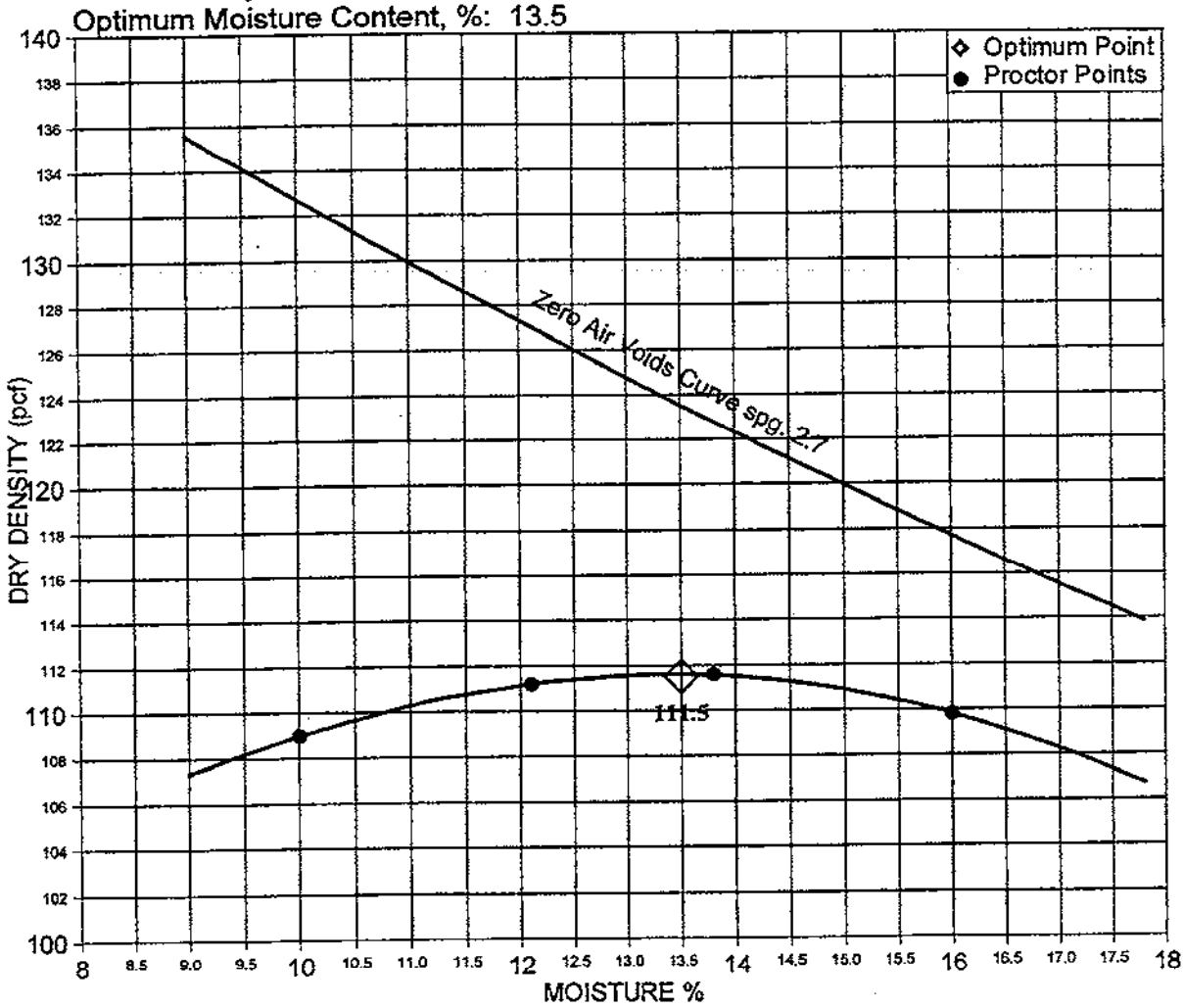
Method B

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/10/01
Tested By: JD - Strata
Sample Number: B1L1744A
Sample Location: 18-5
Sample Description: Silt w/15% Pea Gravel
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch	100	100
#4 screen		

Maximum Dry Density, pcf : 111.5
Optimum Moisture Content, %: 13.5



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

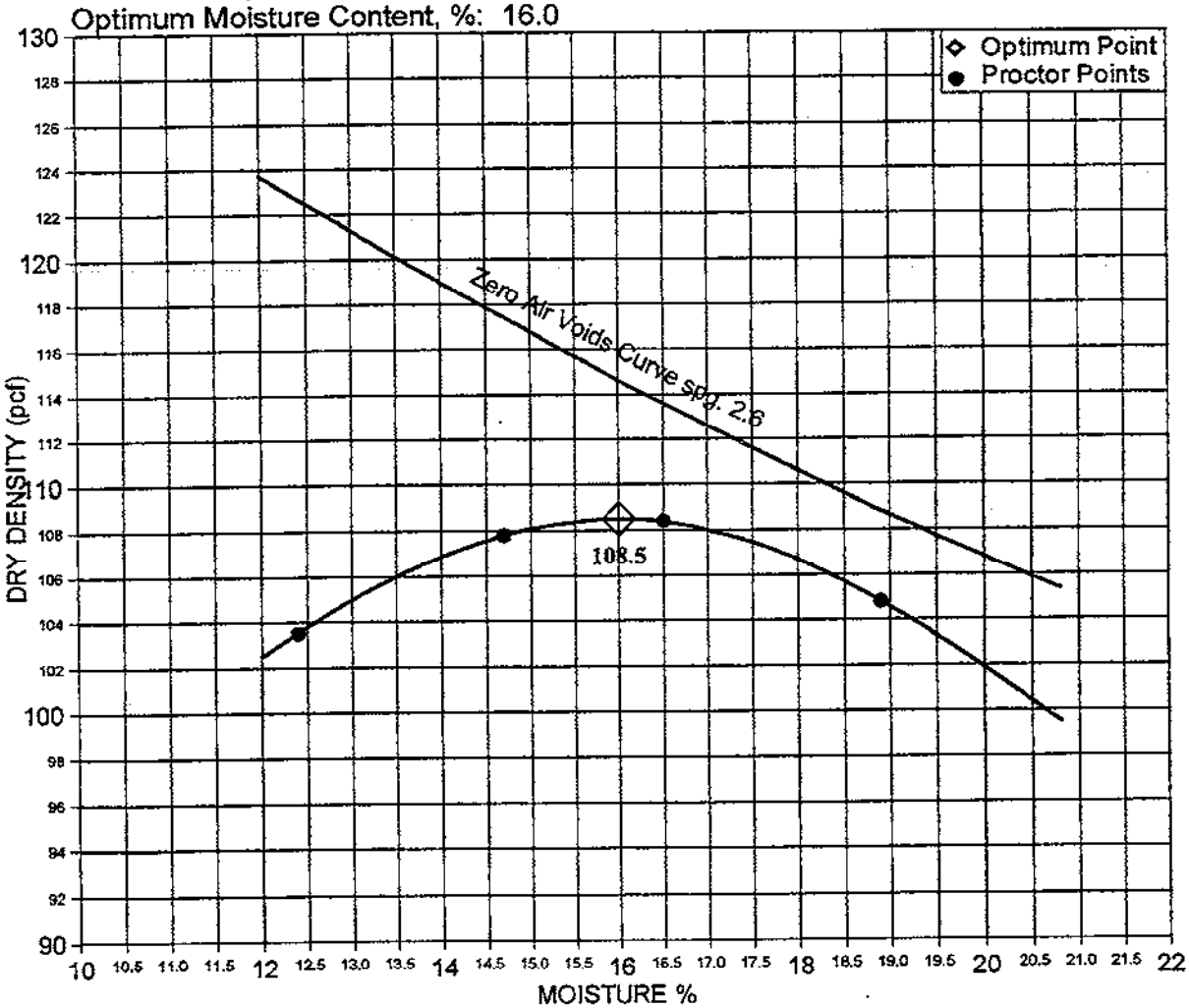
Method A

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/9/01
Tested By: CV - Strata
Sample Number: B1L1745
Sample Location: Test Hole 18-6
Sample Description: Clayey Silt
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch		
#4 screen	100	100

Maximum Dry Density, pcf : 108.5
Optimum Moisture Content, %: 16.0



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GEOTECHNICAL ENGINEERING & MATERIALS TESTING

MOISTURE-DENSITY RELATIONSHIP CURVE

ASTM D 698

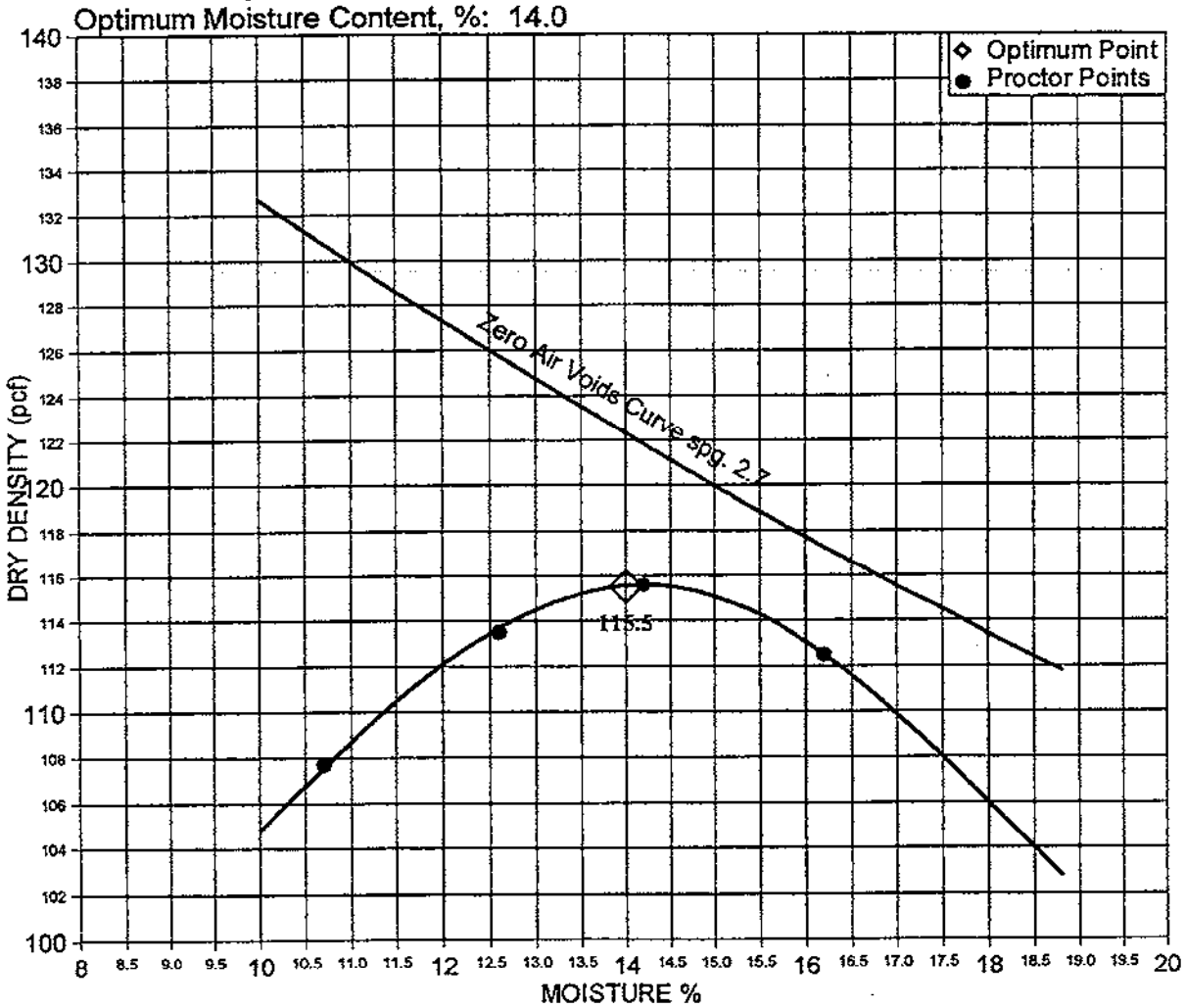
Method B

Project: FMC Pond Closure
Client: A & E Engineering
File Name: AEENGR P01081A
Date Tested: 8/13/01
Tested By: CV - Strata
Sample Number: B1L1745A
Sample Location: Test Hole 18-6
Sample Description: Clayey Silt w/15% Pea Gravel
Soil Tempered: Yes
Rammer Type: Manual

GRADING ANALYSIS

SCREEN SIZE	% PASSING	AS TESTED
6 inch		
4 inch		
2 inch		
3/4 inch		
3/8 inch	100	100
#4 screen		

Maximum Dry Density, pcf : 115.5
Optimum Moisture Content, %: 14.0



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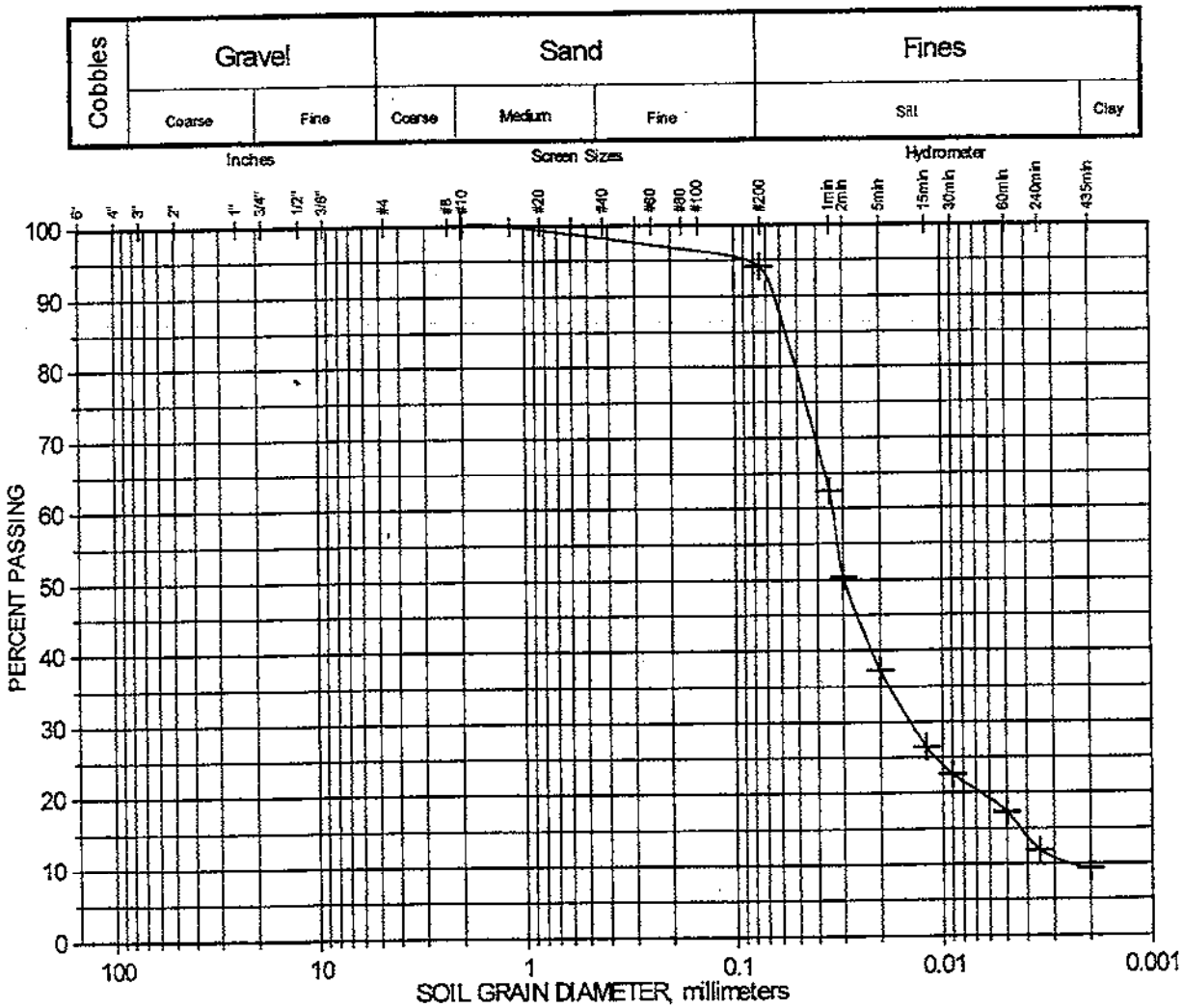
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS
ASTM D422

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closure
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1740
Sample Location: 18-1
Description: Silt
Date Received: 8/8/01
Date tested: 8/10 by PV



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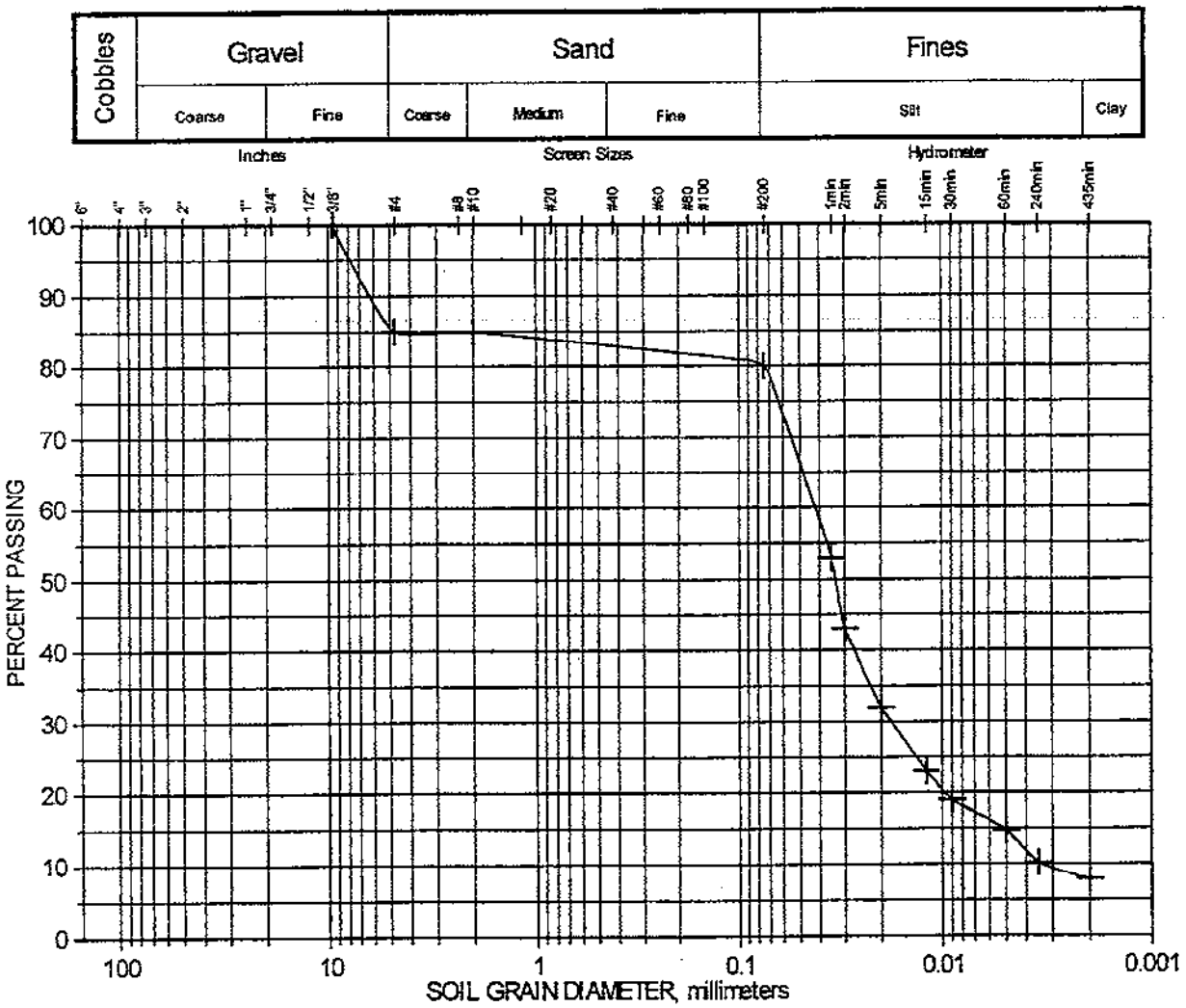
STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closure
Client: A&E Engineering
File: AEENGR_P01081A
Sample No.: B1L1740
Sample Location: 18-1
Description: Silt w/15% Pea Gravel
Date Received: 8/8/01
Date tested: 8/10 by PV



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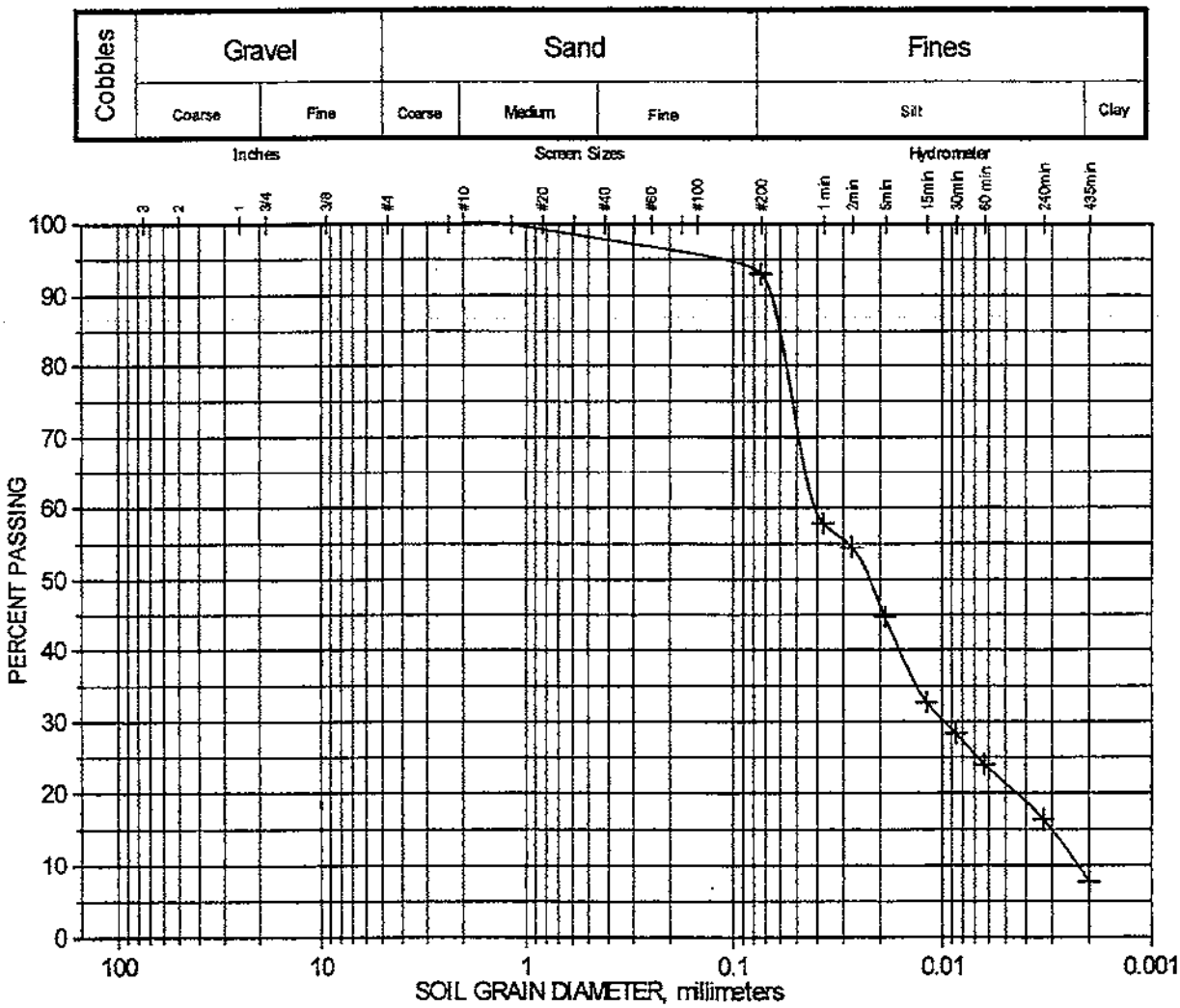
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1741
Sample Location: TH 18-2
Description: Silt
Date tested: 8/10/01



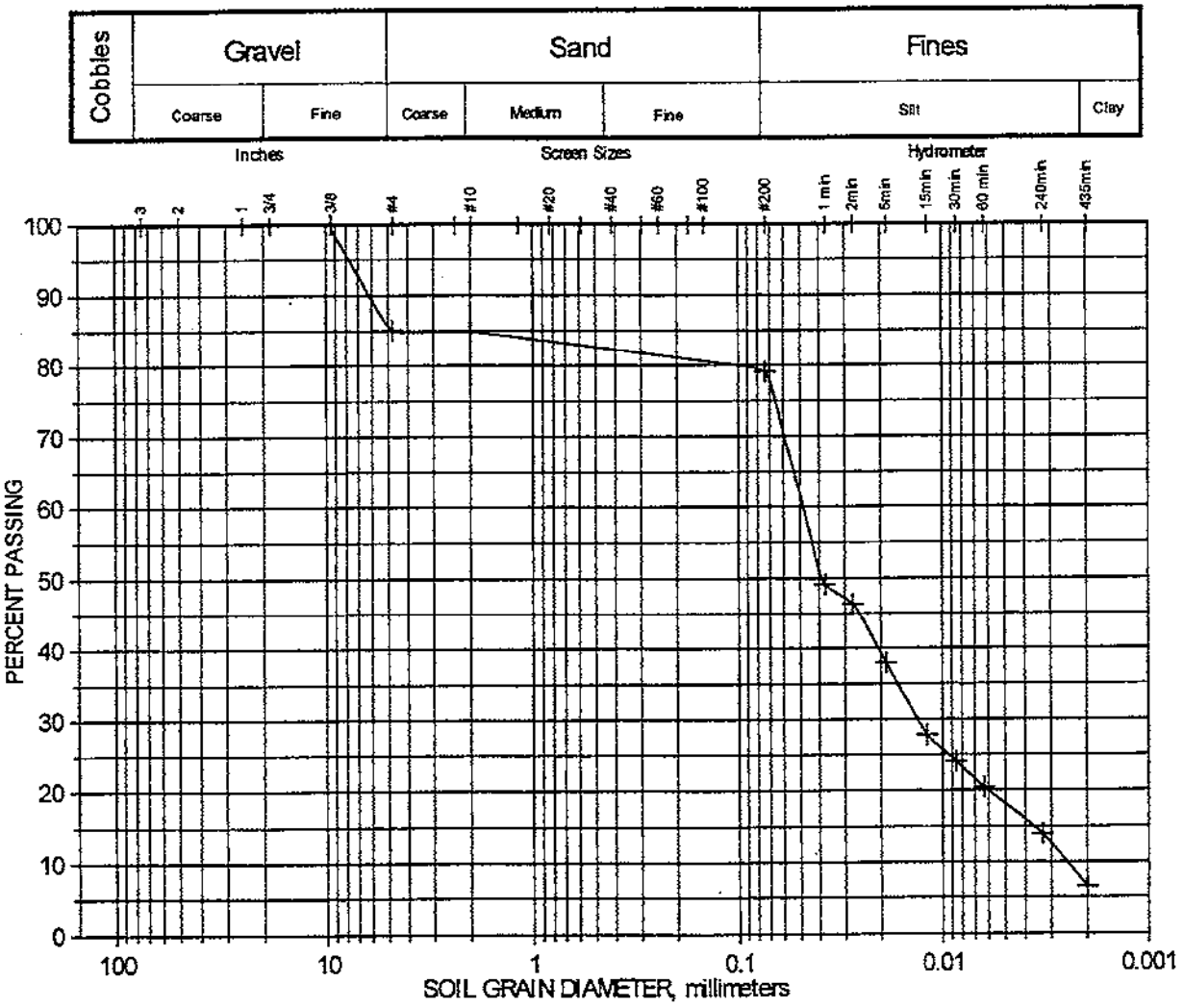
Reviewed by: _____

STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
~~File: AEENGR P01081A~~
Sample No.: B1L1741
Sample Location: TH 18-2
Description: Silt w/15% Pea Gravel
Date tested: 8/10/01



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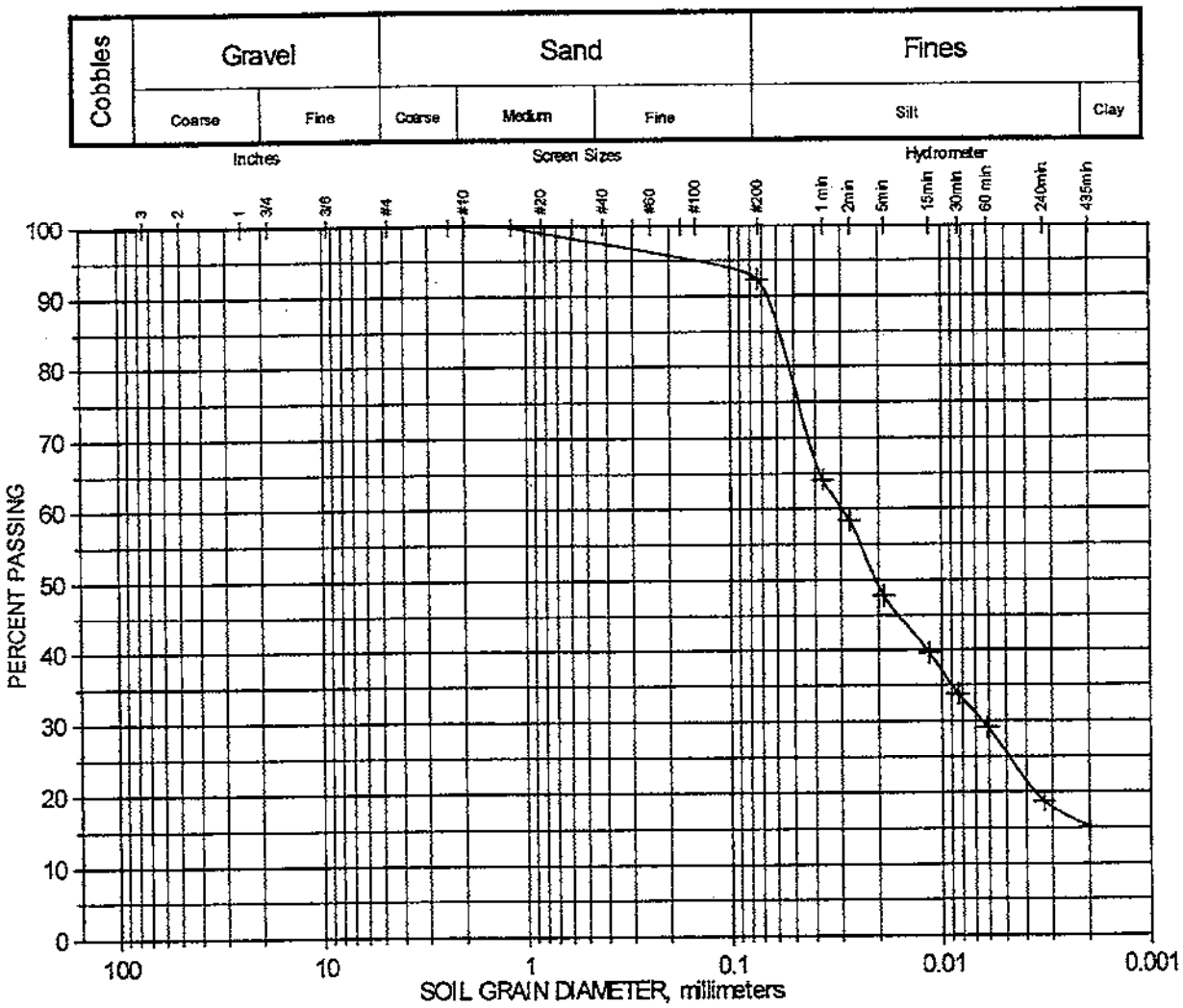
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
~~File: AEENGR P01081A~~
Sample No.: B1L1742
Sample Location: TH 18-3
Description: Calcitic Silt
Date tested: 8/10/01



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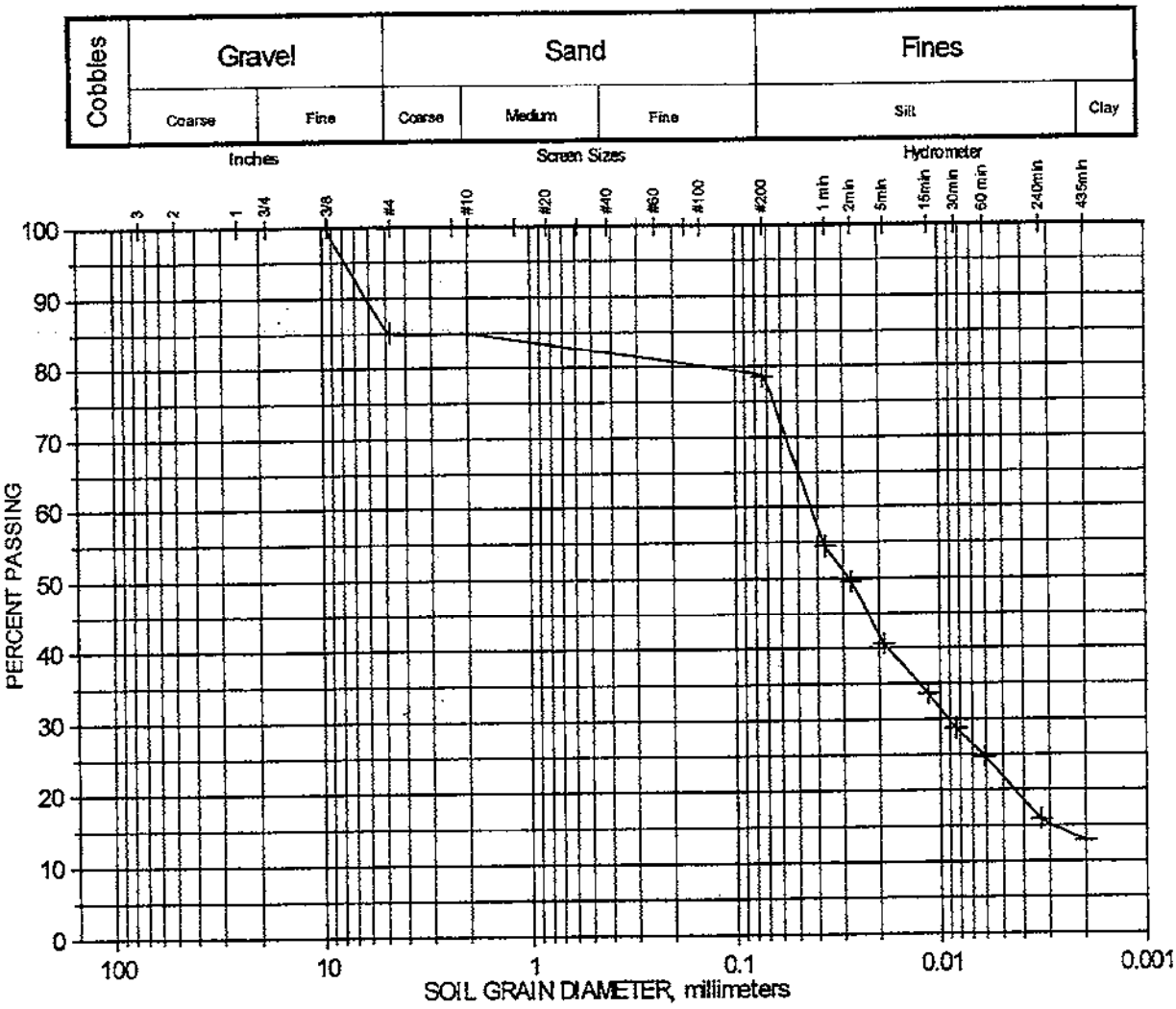
STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1742
Sample Location: TH 18-3
Description: Calcitic Silt w/15% Pea Gravel
Date tested: 8/10/01



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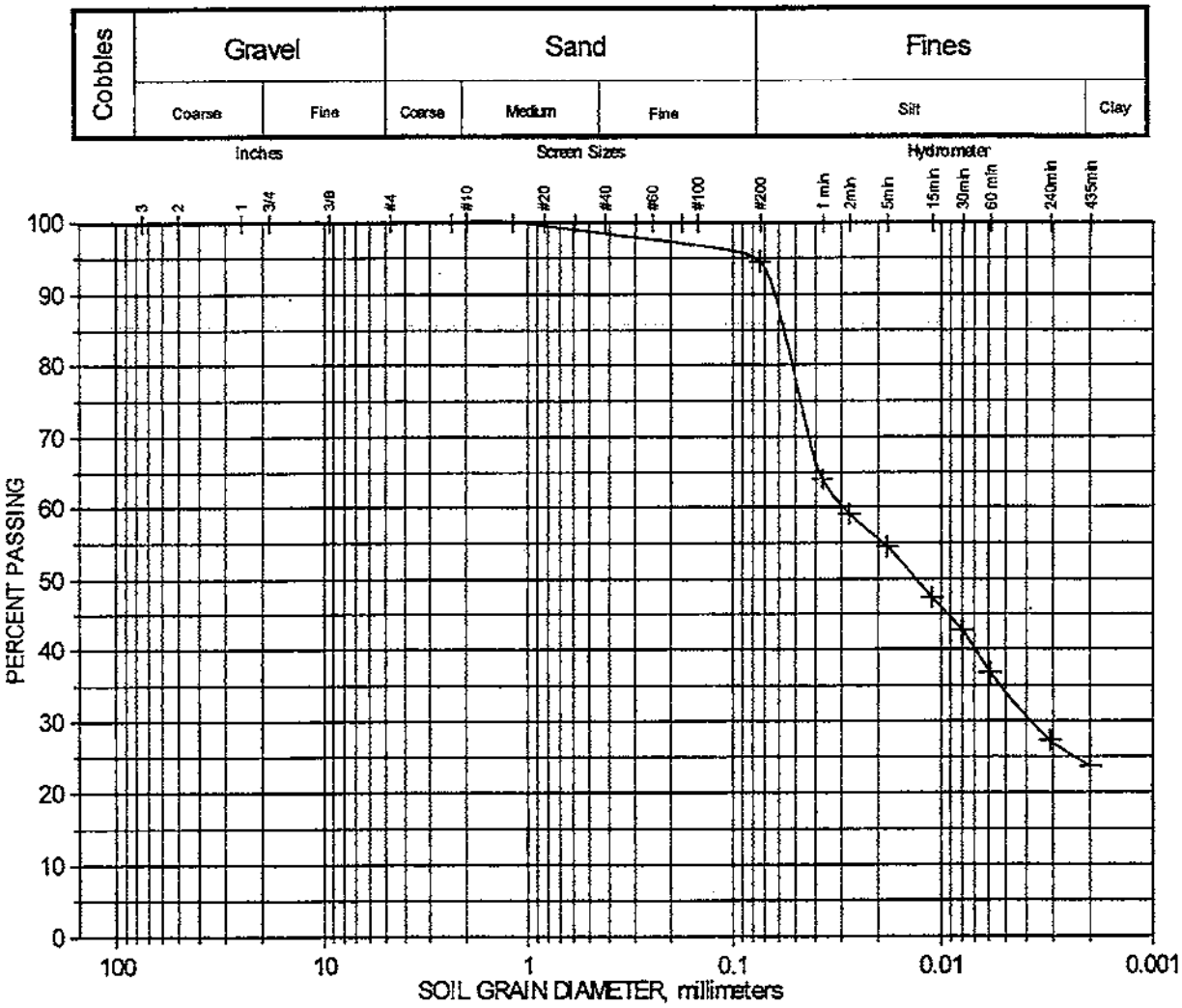
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR-P01081A
Sample No.: B1L1743
Sample Location: TH 18-4
Description: Clayey Silt
Date tested: 8/10/01



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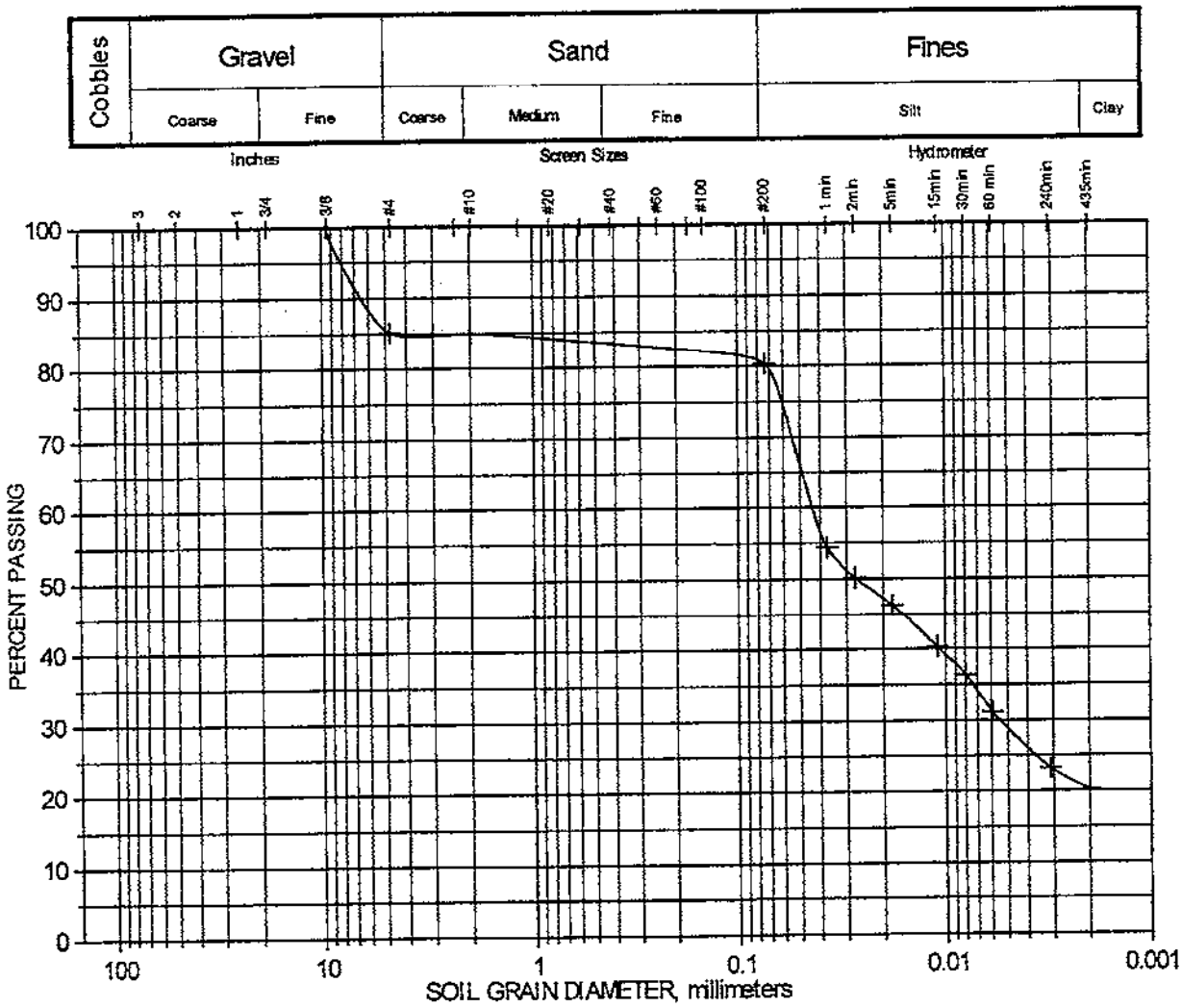
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
~~File: AEENGR P01081A~~
Sample No.: B1L1743
Sample Location: TH 18-4
Description: Clayey Silt w/15% Pea Gravel
Date tested: 8/10/01



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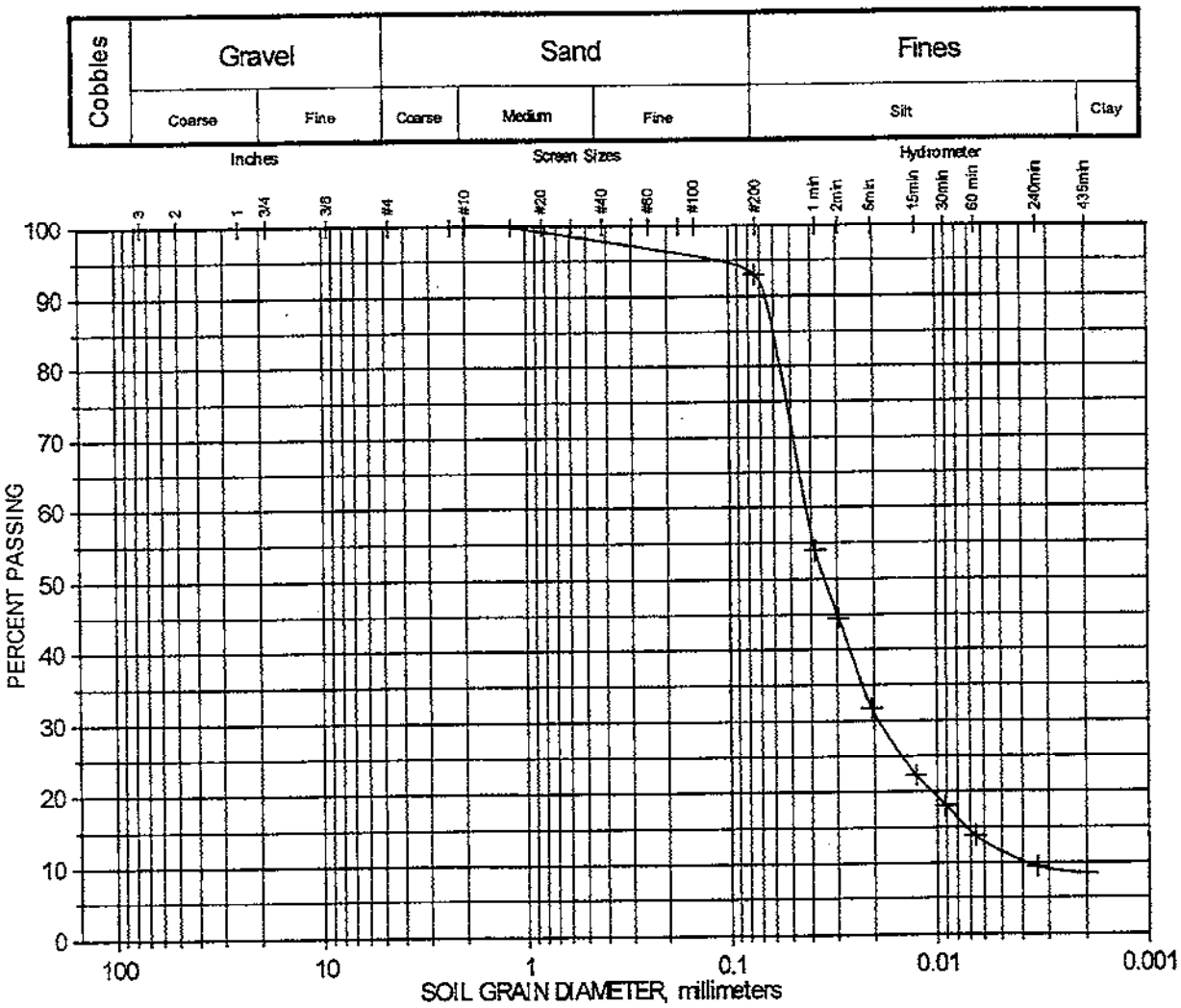
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1744
Sample Location: TH 18-5
Description: Silt
Date tested: 8/10/01



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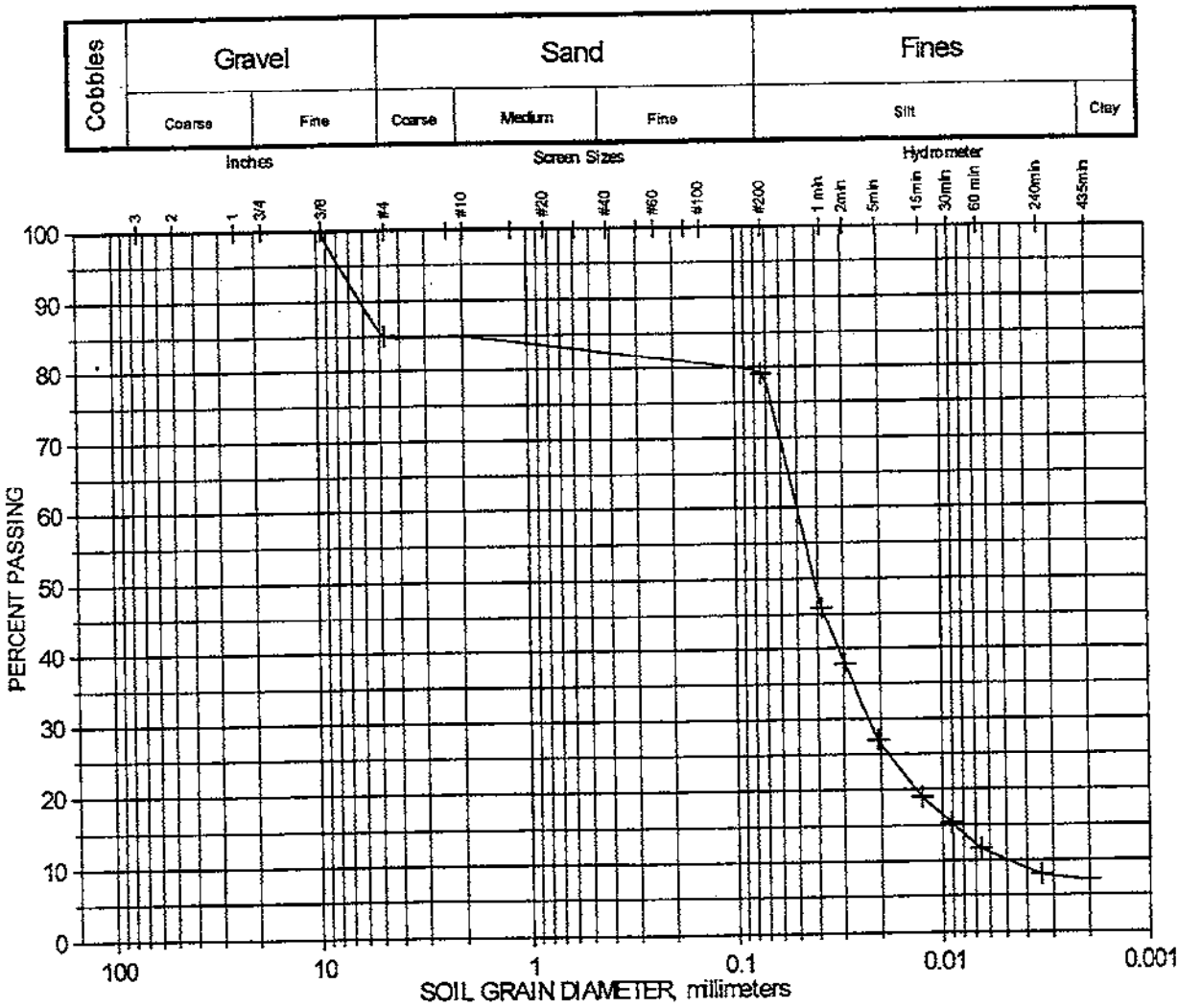
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1744
Sample Location: TH 18-5
Description: Silt w/Pea Gravel
Date tested: 8/10/01



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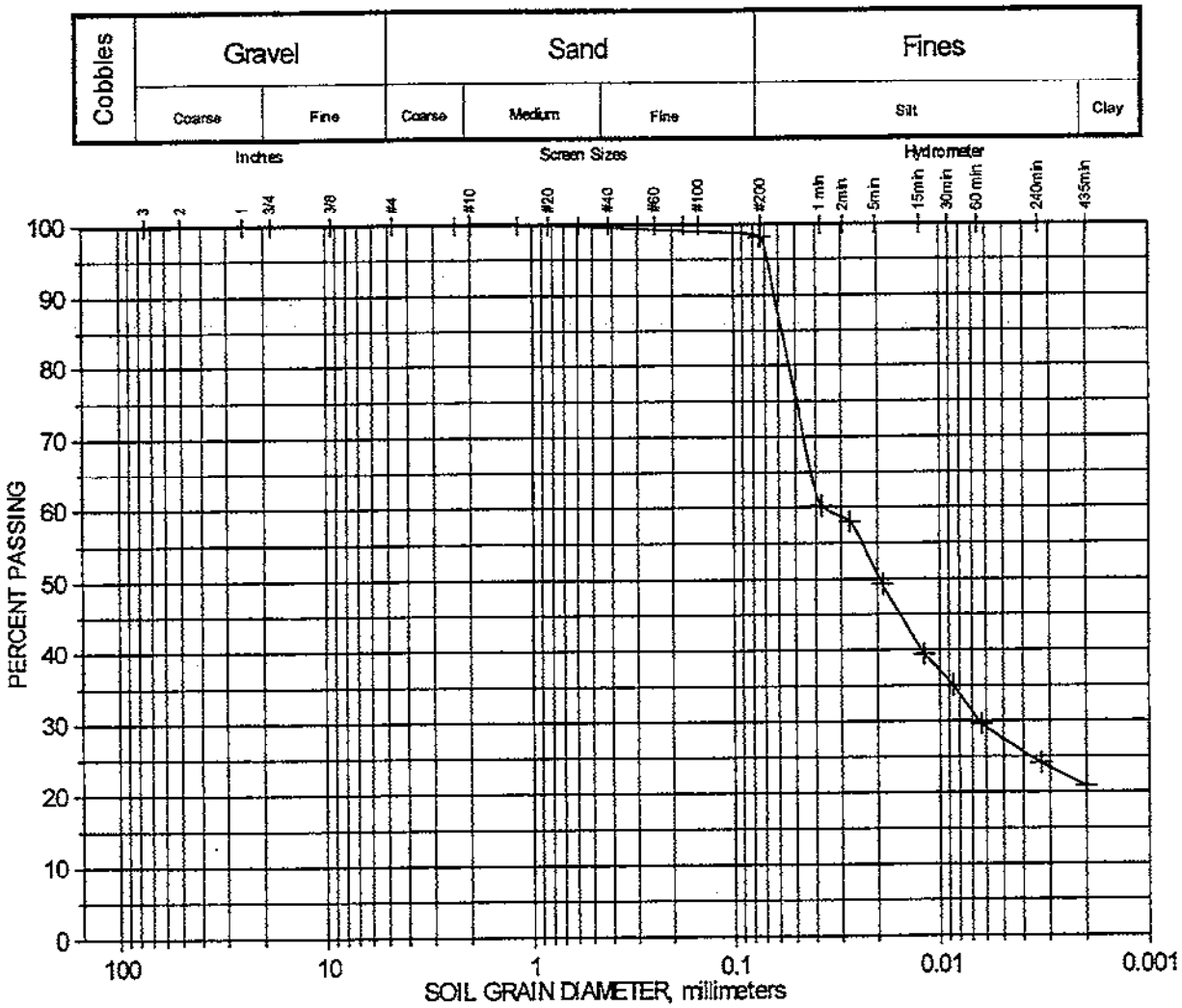
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1745
Sample Location: TH 18-6
Description: Clayey Silt
Date tested: 8/10/01



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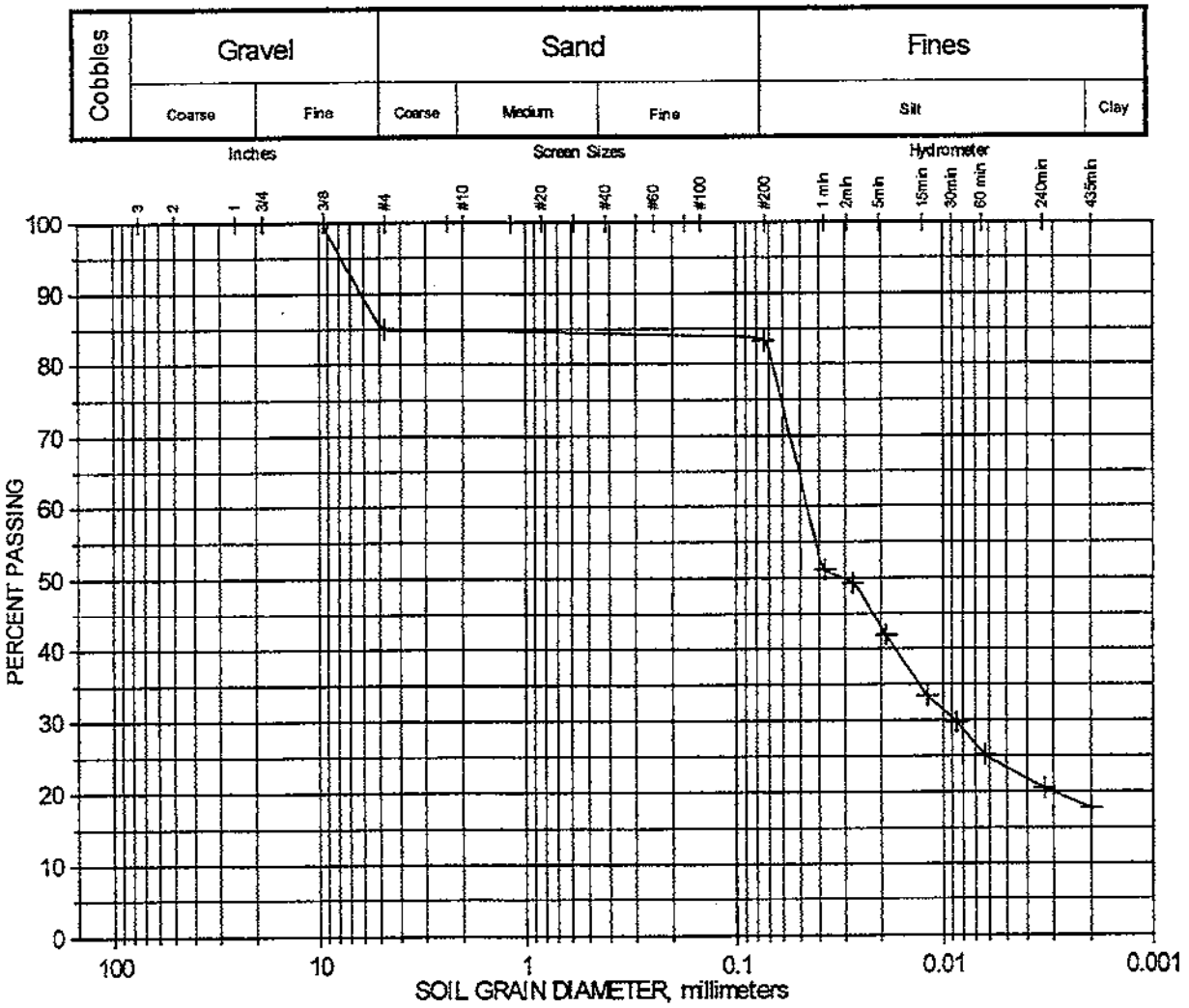
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

GRADATION ANALYSIS

ASTM D422

Project: FMC Pond Closures
Client: A&E Engineering
File: AEENGR P01081A
Sample No.: B1L1745
Sample Location: TH 18-6
Description: Clayey Silt w/Pea Gravel
Date tested: 8/10/01



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STRATA
GEOTECHNICAL ENGINEERING & MATERIALS TESTING

CAPILLARY-MOISTURE RELATIONS
ASTM D 3152

CAPILLARY-MOISTURE RELATIONS

Sample 18-1, at 80 % Mdd

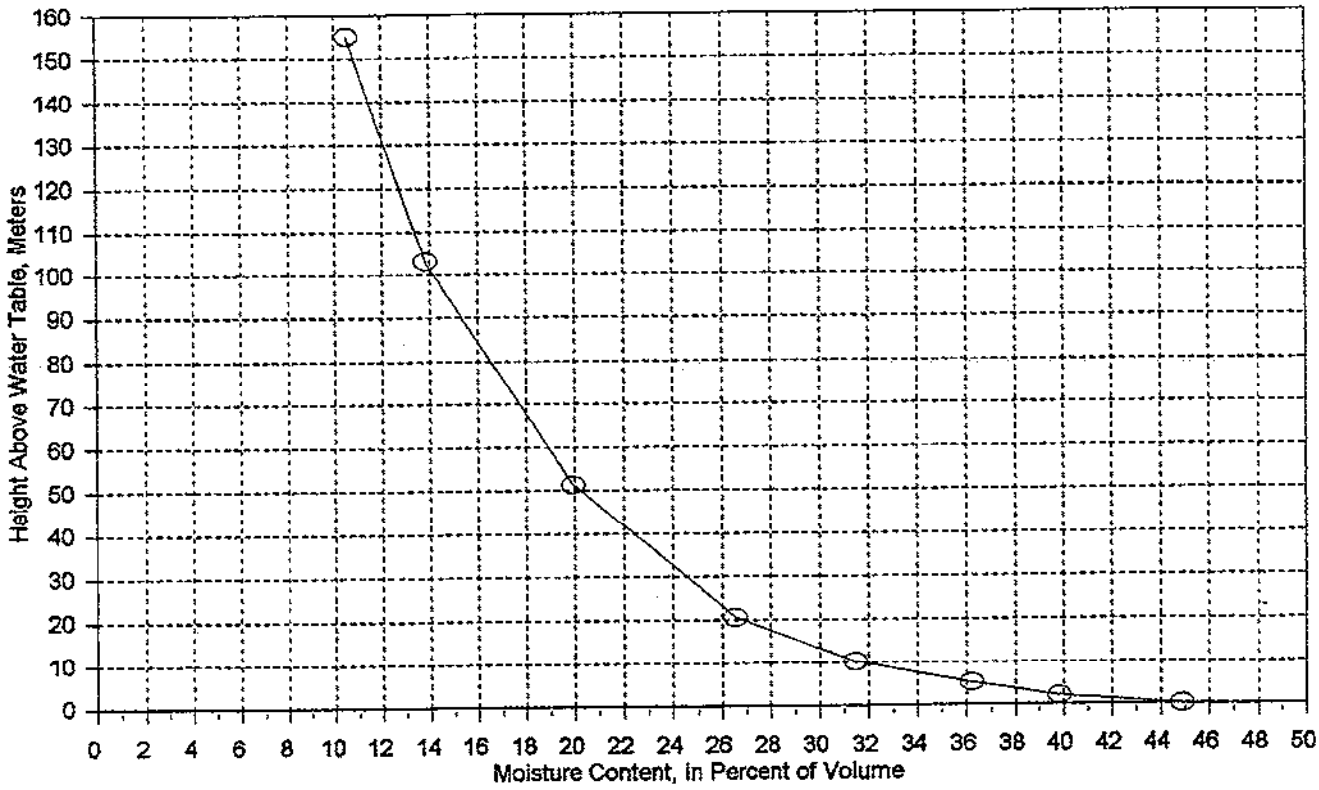

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-1, at 80 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	33.08	38.03	36.99	36.24	35.27	34.25	32.89	31.62	30.95
(5)	4.3	9.25	8.21	7.46	6.49	5.47	4.11	2.84	2.17
(7)	28.78	28.78	28.78	28.78	28.78	28.78	28.78	28.78	28.78
(8)	14.94	32.14	28.53	25.92	22.55	19.01	14.28	9.87	7.54
(9)	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
(10)	20.88	44.91	39.86	36.22	31.51	26.56	19.95	13.79	10.53

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 23

CAPILLARY-MOISTURE RELATIONS

Sample 18-1, at 85 % Mdd

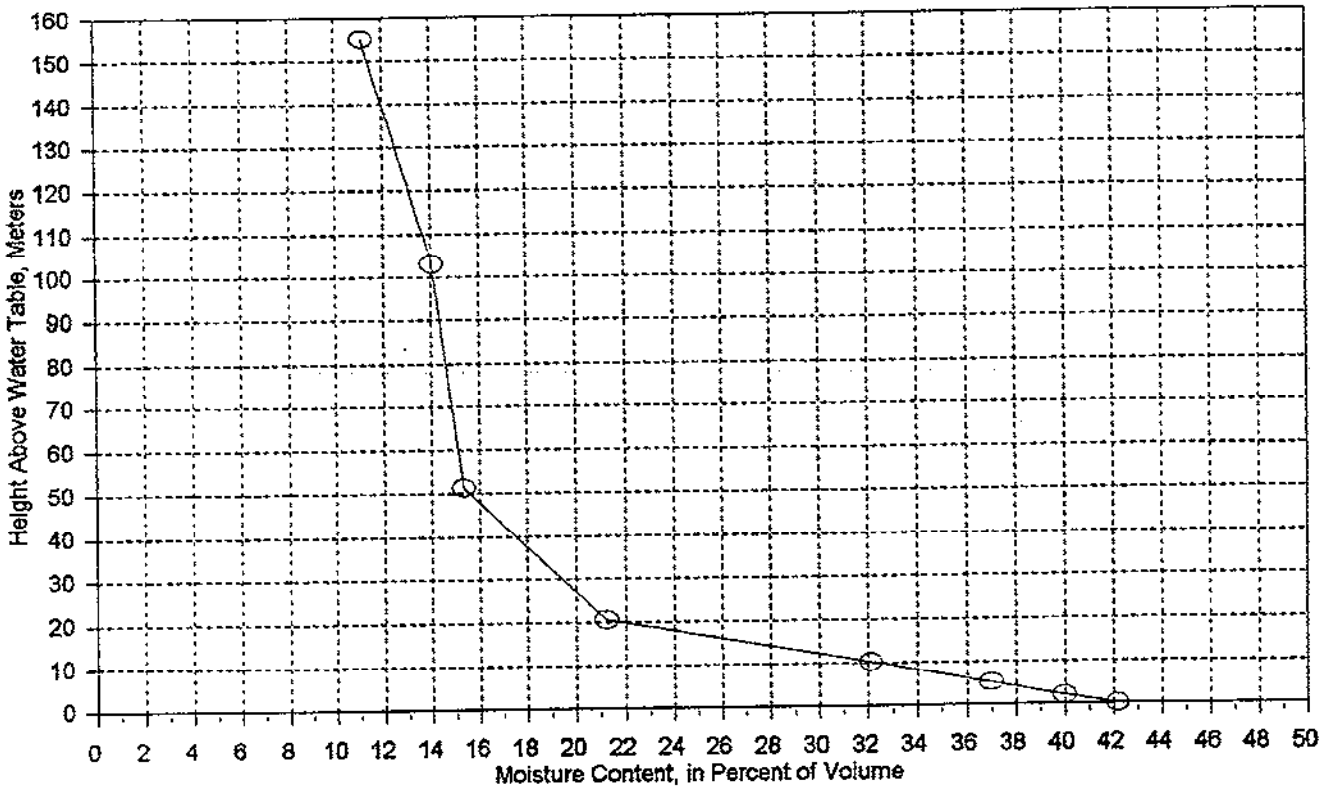

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-1, at 85 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	35.38	39.3	38.85	38.23	37.23	34.98	33.77	33.5	32.91
(5)	4.77	8.69	8.24	7.62	6.62	4.37	3.16	2.89	2.3
(7)	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61
(8)	15.58	28.39	26.92	24.89	21.63	14.28	10.32	9.44	7.51
(9)	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
(10)	23.16	42.19	40.00	36.99	32.14	21.22	15.34	14.03	11.17

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 34

CAPILLARY-MOISTURE RELATIONS

Sample 18-1, at 80 % Mdd w 15 % gravel

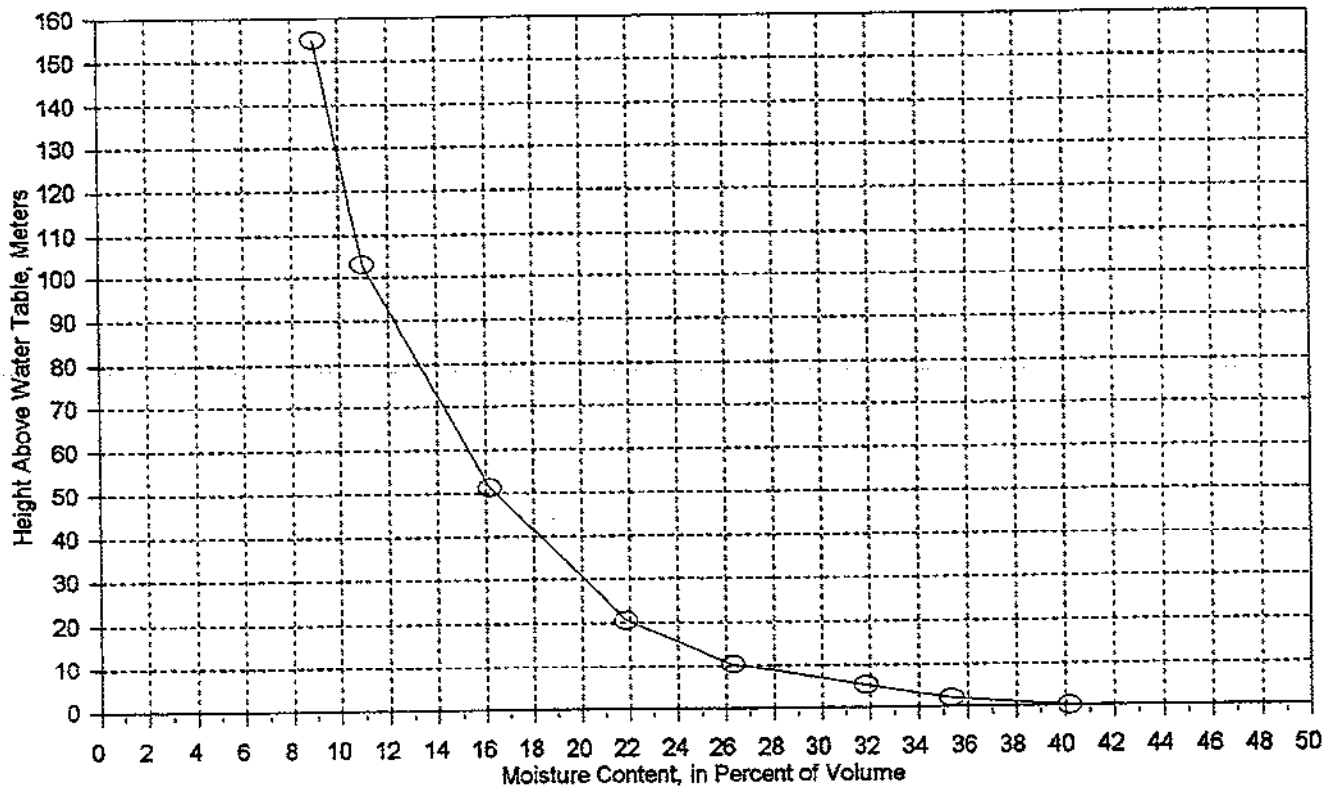

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-1, at 80 % w15% gvl

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	34.18	38.18	37.18	36.46	35.32	34.4	33.23	32.16	31.75
(5)	4.28	8.28	7.28	6.56	5.42	4.5	3.33	2.26	1.85
(7)	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9
(8)	14.31	27.69	24.35	21.94	18.13	15.05	11.14	7.56	6.19
(9)	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
(10)	20.78	40.20	35.34	31.85	26.31	21.85	16.17	10.97	8.98

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 35

CAPILLARY-MOISTURE RELATIONS

Sample 18-2, at 80 % Mdd

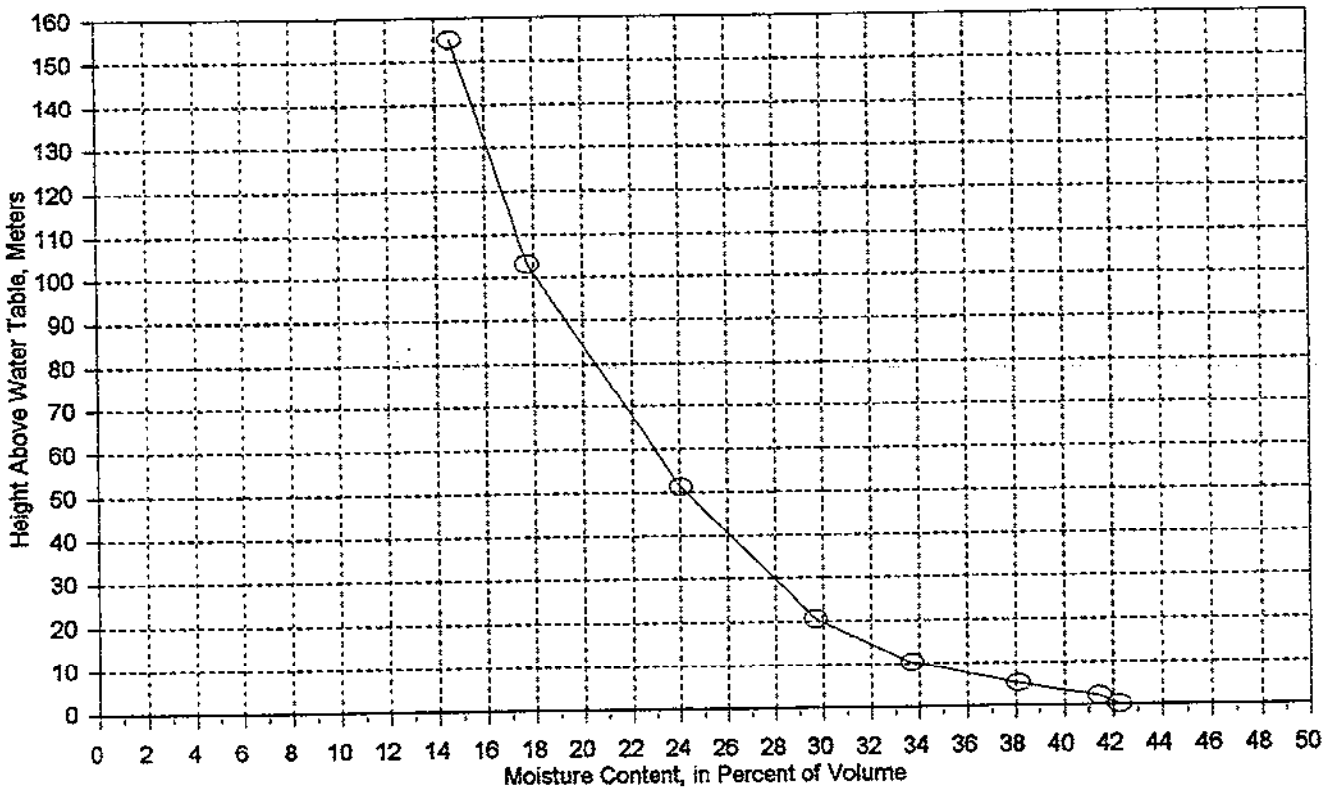

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-2, at 80 %

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	32.24	36.43	36.26	35.57	34.67	33.84	32.67	31.37	30.73
(5)	4.52	8.71	8.54	7.85	6.95	6.12	4.95	3.65	3.01
(7)	27.72	27.72	27.72	27.72	27.72	27.72	27.72	27.72	27.72
(8)	16.31	31.42	30.81	28.32	25.07	22.08	17.86	13.17	10.86
(9)	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35
(10)	21.94	42.28	41.46	38.11	33.74	29.71	24.03	17.72	14.61

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 12

CAPILLARY-MOISTURE RELATIONS

Sample 18-2, at 85 % Mdd

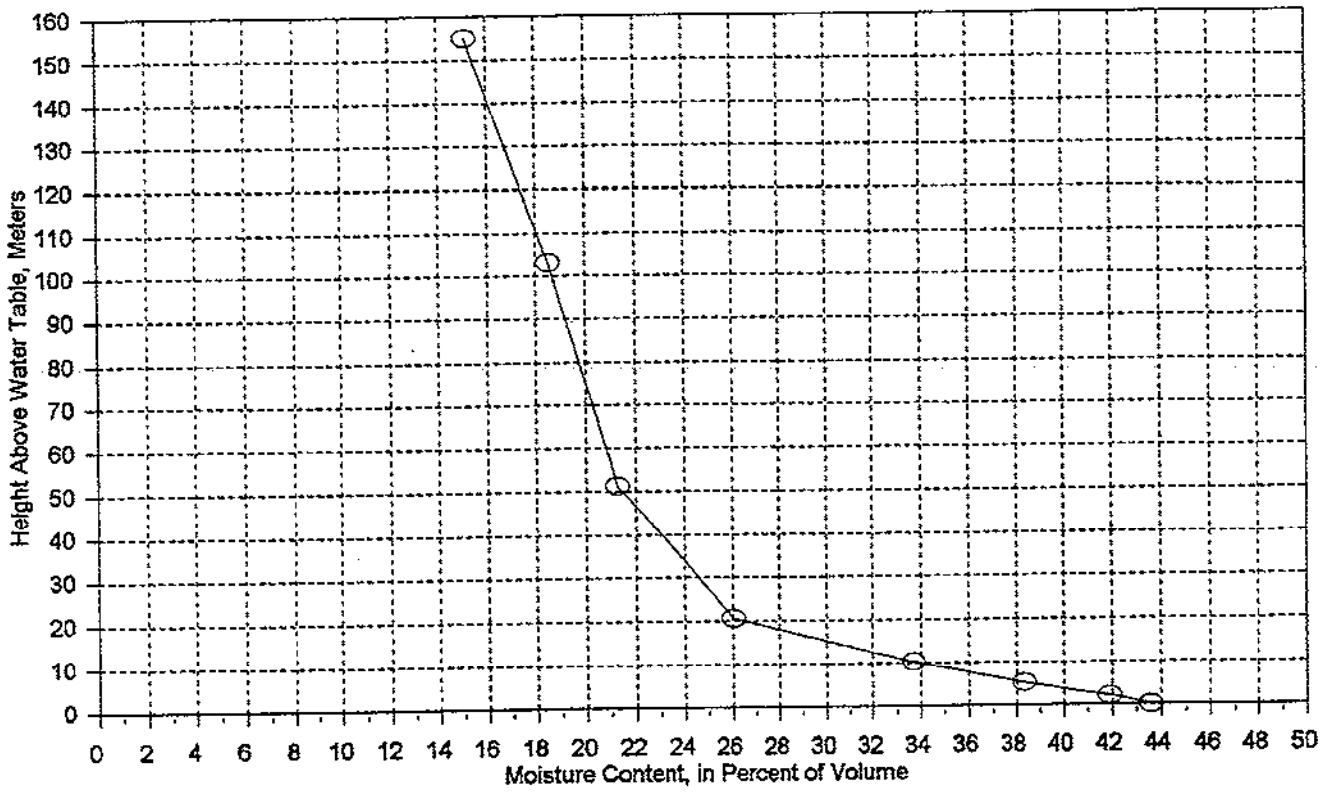

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-2, at 85 %

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	34.19	38.39	38.05	37.31	36.36	34.78	33.79	33.22	32.53
(5)	4.78	8.98	8.64	7.9	6.95	5.37	4.38	3.81	3.12
(7)	29.41	29.41	29.41	29.41	29.41	29.41	29.41	29.41	29.41
(8)	16.25	30.53	29.38	26.86	23.63	18.26	14.89	12.95	10.61
(9)	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
(10)	23.21	43.60	41.95	38.35	33.74	26.07	21.26	18.50	15.15

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 41

CAPILLARY-MOISTURE RELATIONS

Sample 18-2, at 80 % Mdd w gravel

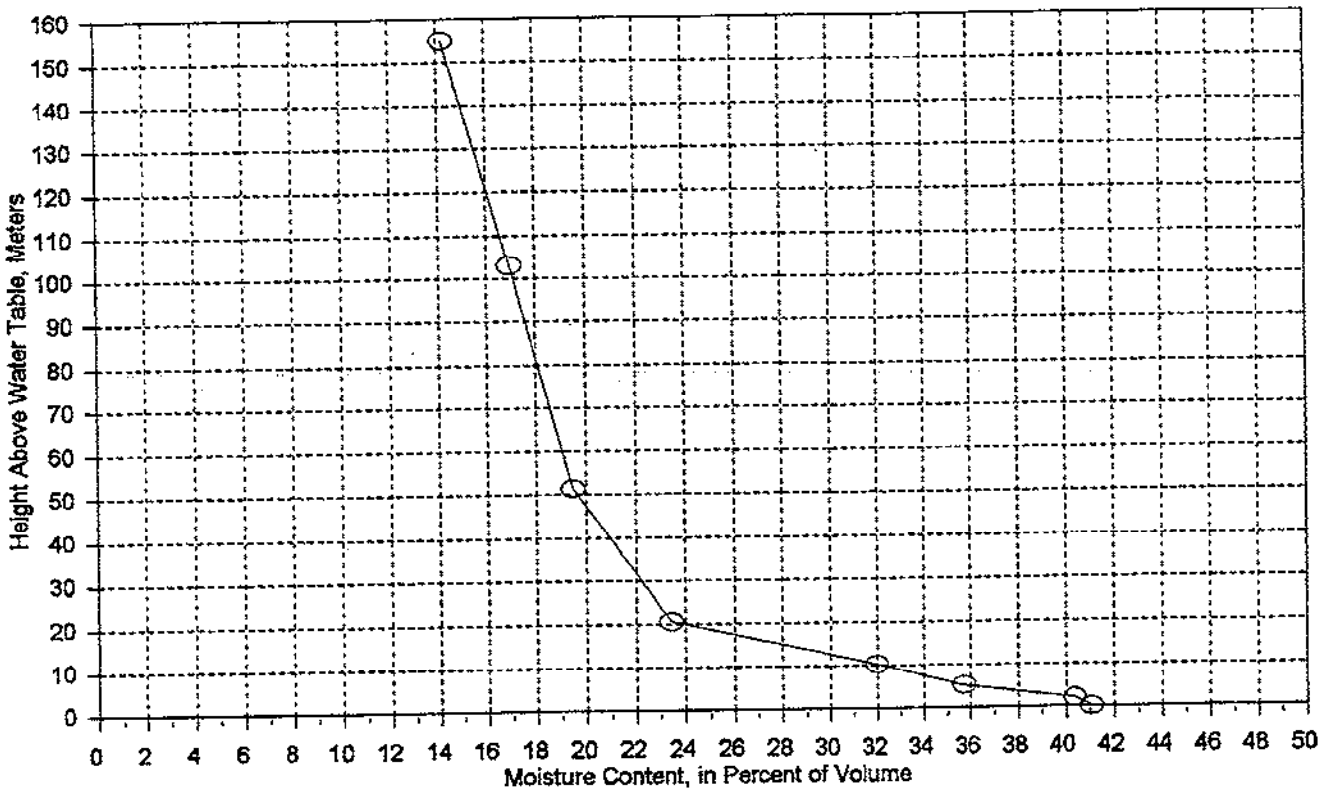

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-2, at 80 % w gravel

Height m	0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar	0	0.2	0.5	1	2	5	10	15
(3)	33.63	38.03	37.89	36.93	36.16	34.4	33.58	33.06	32.5
(5)	4.06	8.46	8.32	7.36	6.59	4.83	4.01	3.49	2.93
(7)	29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57
(8)	13.73	28.61	28.14	24.89	22.29	16.33	13.56	11.80	9.91
(9)	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
(10)	19.71	41.07	40.39	35.73	31.99	23.45	19.47	16.94	14.22

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 3

CAPILLARY-MOISTURE RELATIONS

Sample 18-3, at 80 % Mdd

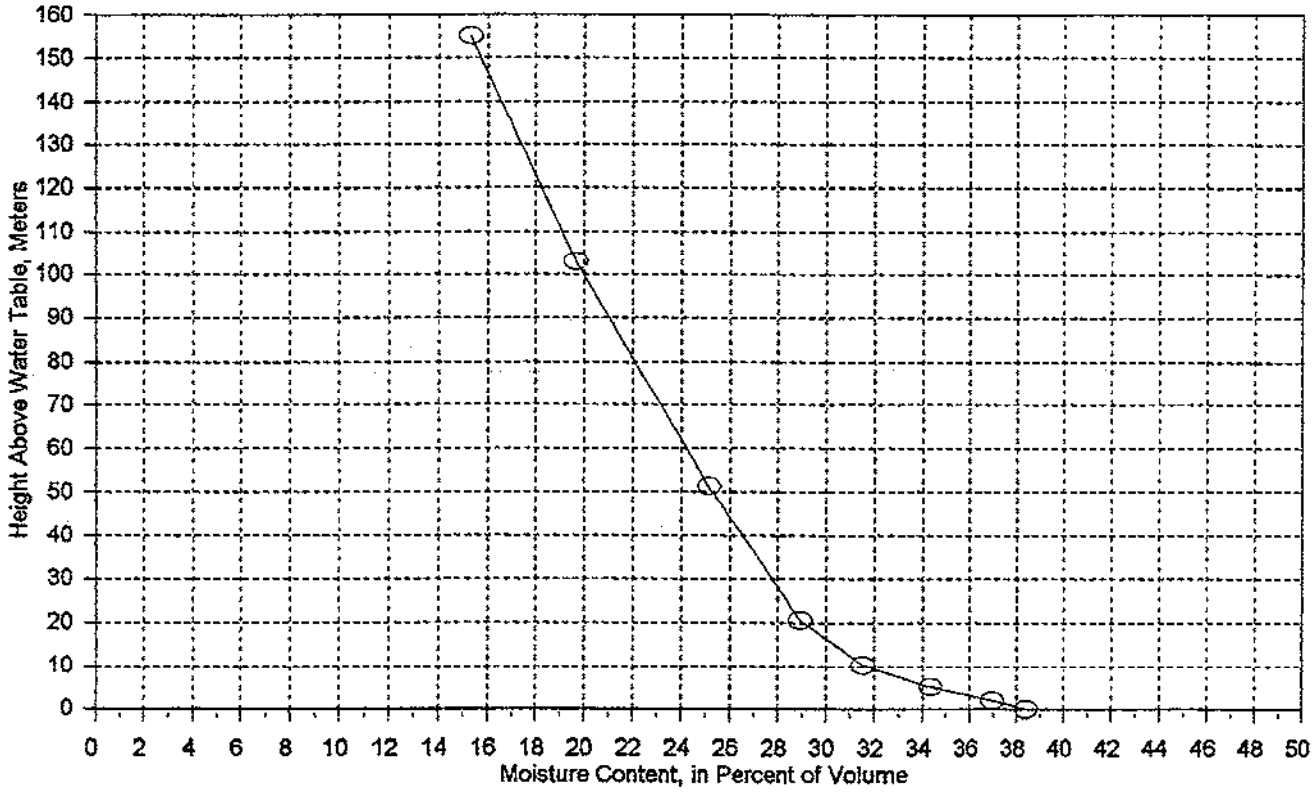

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-3, at 80 %

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	31.23	33.8	33.51	32.97	32.39	31.86	31.07	29.94	29.04
(5)	5.34	7.91	7.62	7.08	6.5	5.97	5.18	4.05	3.15
(7)	25.89	25.89	25.89	25.89	25.89	25.89	25.89	25.89	25.89
(8)	20.63	30.55	29.43	27.35	25.11	23.06	20.01	15.64	12.17
(9)	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
(10)	25.92	38.40	36.99	34.37	31.56	28.98	25.15	19.66	15.29

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 1

CAPILLARY-MOISTURE RELATIONS

Sample 18-3, at 85 % Mdd

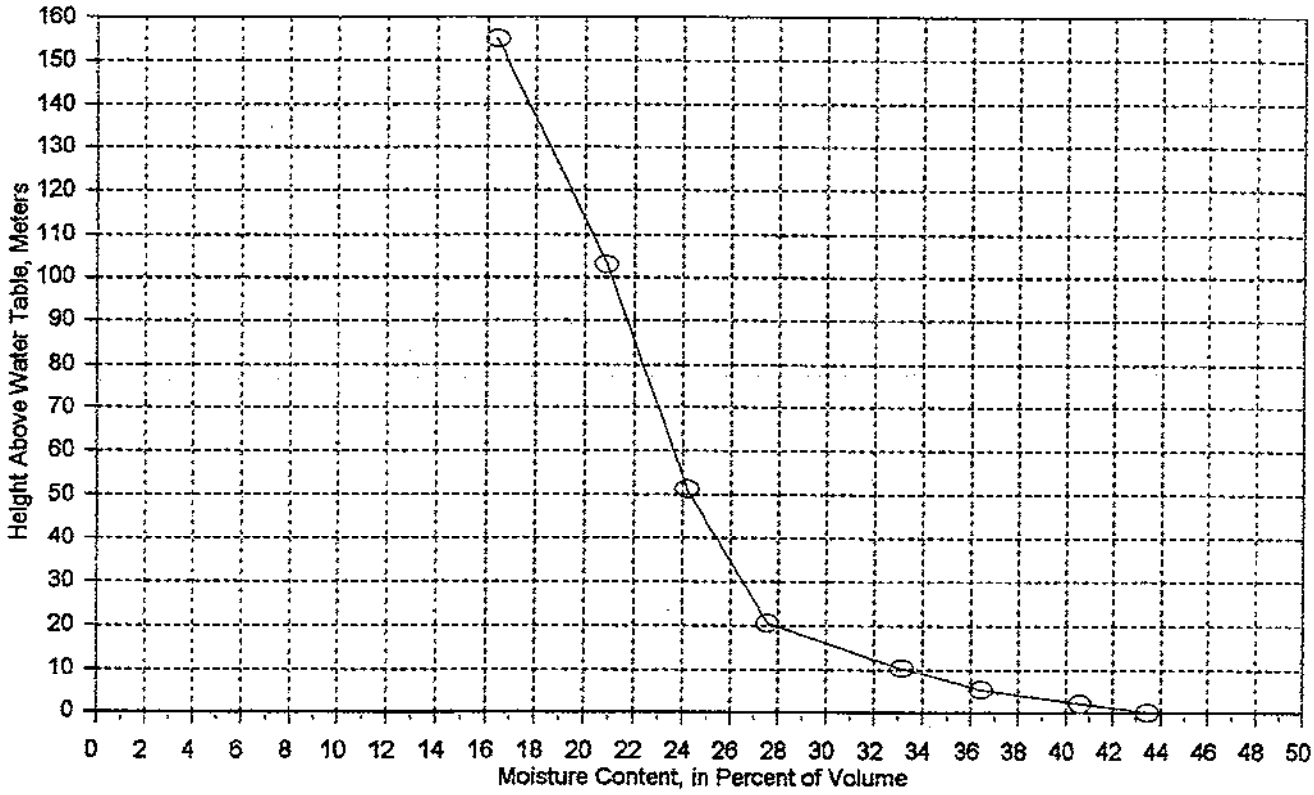

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-3, at 85 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	33.2	36.56	35.97	35.11	34.43	33.28	32.58	31.9	30.98
(5)	5.6	8.96	8.37	7.51	6.83	5.68	4.98	4.3	3.38
(7)	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6
(8)	20.29	32.46	30.33	27.21	24.75	20.58	18.04	15.58	12.25
(9)	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
(10)	27.19	43.50	40.63	36.46	33.16	27.57	24.18	20.88	16.41

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 42

CAPILLARY-MOISTURE RELATIONS

Sample 18-3, at 80 % Mdd with gravel

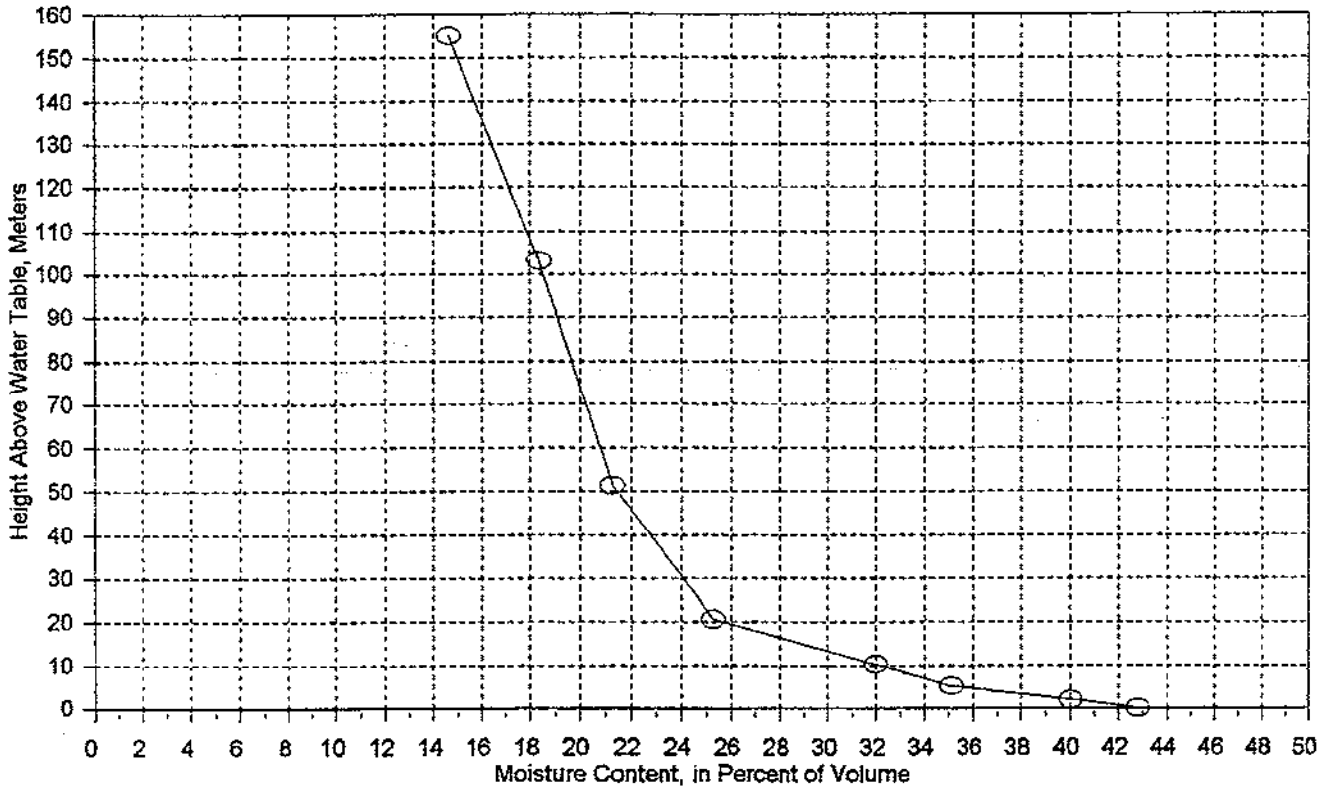

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-3, at 80 % with gravel

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	33.3	37.49	36.92	35.91	35.26	33.88	33.05	32.45	31.68
(5)	4.63	8.82	8.25	7.24	6.59	5.21	4.38	3.78	3.01
(7)	28.67	28.67	28.67	28.67	28.67	28.67	28.67	28.67	28.67
(8)	16.15	30.76	28.78	25.25	22.99	18.17	15.28	13.18	10.50
(9)	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
(10)	22.48	42.82	40.05	35.15	31.99	25.29	21.26	18.35	14.61

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 39

CAPILLARY-MOISTURE RELATIONS

Sample 18-4, at 80 % Mdd

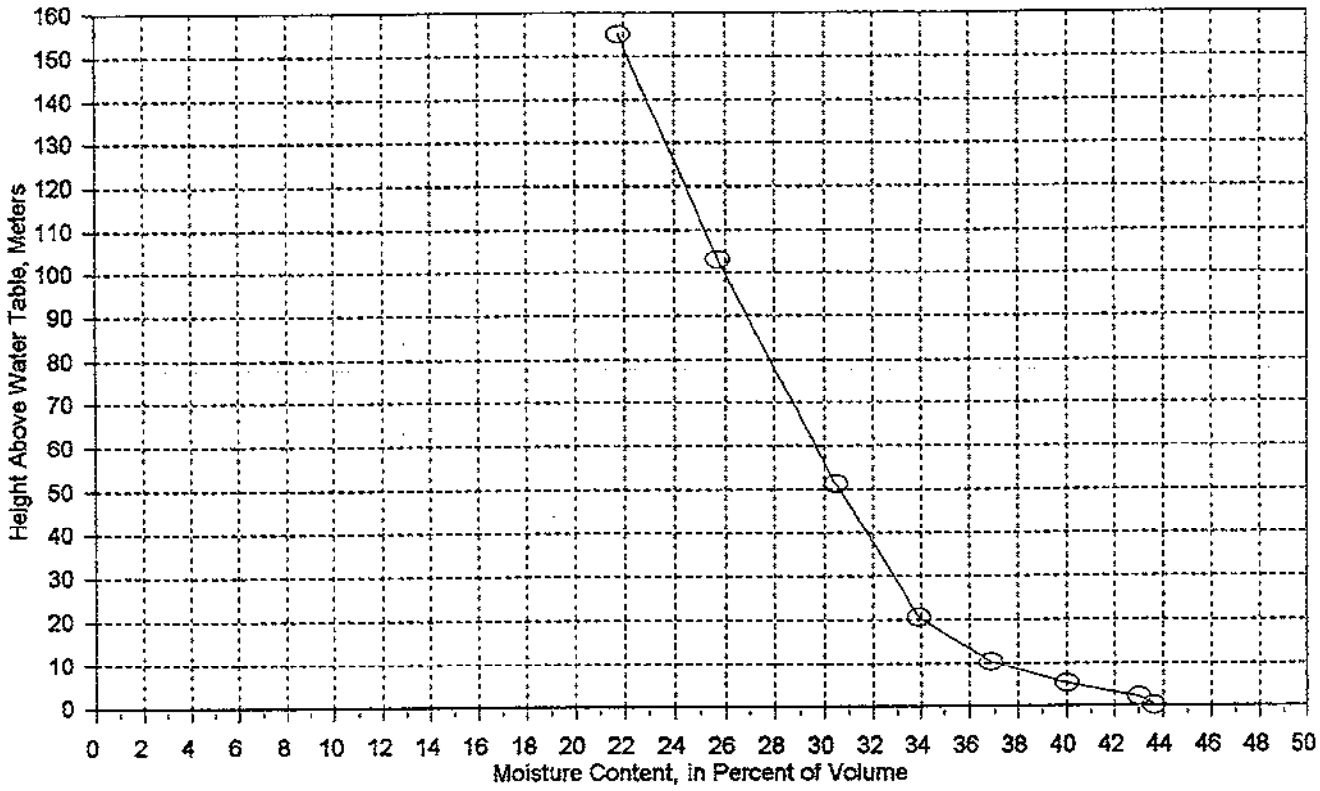

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-4, at 80 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	31.93	35.78	35.65	35.04	34.39	33.78	33.07	32.09	31.28
(5)	5.14	8.99	8.86	8.25	7.6	6.99	6.28	5.3	4.49
(7)	26.79	26.79	26.79	26.79	26.79	26.79	26.79	26.79	26.79
(8)	19.19	33.56	33.07	30.80	28.37	26.09	23.44	19.78	16.76
(9)	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
(10)	24.95	43.64	43.01	40.05	36.90	33.93	30.49	25.73	21.80

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 26

CAPILLARY-MOISTURE RELATIONS

Sample 18-4, at 85 % Mdd

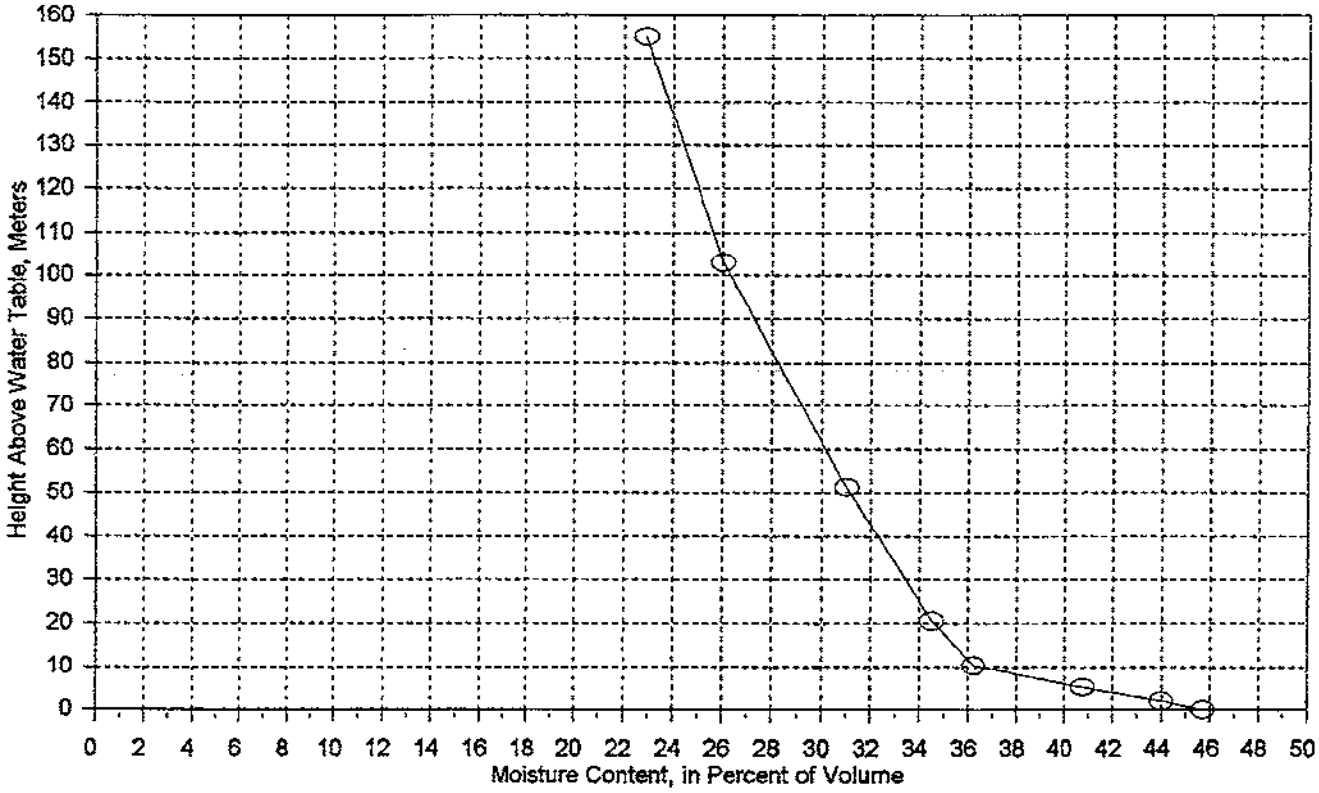

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-4, at 85 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	34.04	37.9	37.55	36.89	35.95	35.59	34.87	33.85	33.2
(5)	5.56	9.42	9.07	8.41	7.47	7.11	6.39	5.37	4.72
(7)	28.48	28.48	28.48	28.48	28.48	28.48	28.48	28.48	28.48
(8)	19.52	33.08	31.85	29.53	26.23	24.96	22.44	18.86	16.57
(9)	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38
(10)	26.99	45.73	44.03	40.83	36.26	34.52	31.02	26.07	22.91

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 37

CAPILLARY-MOISTURE RELATIONS

Sample 18-4, at 80 % with gravel

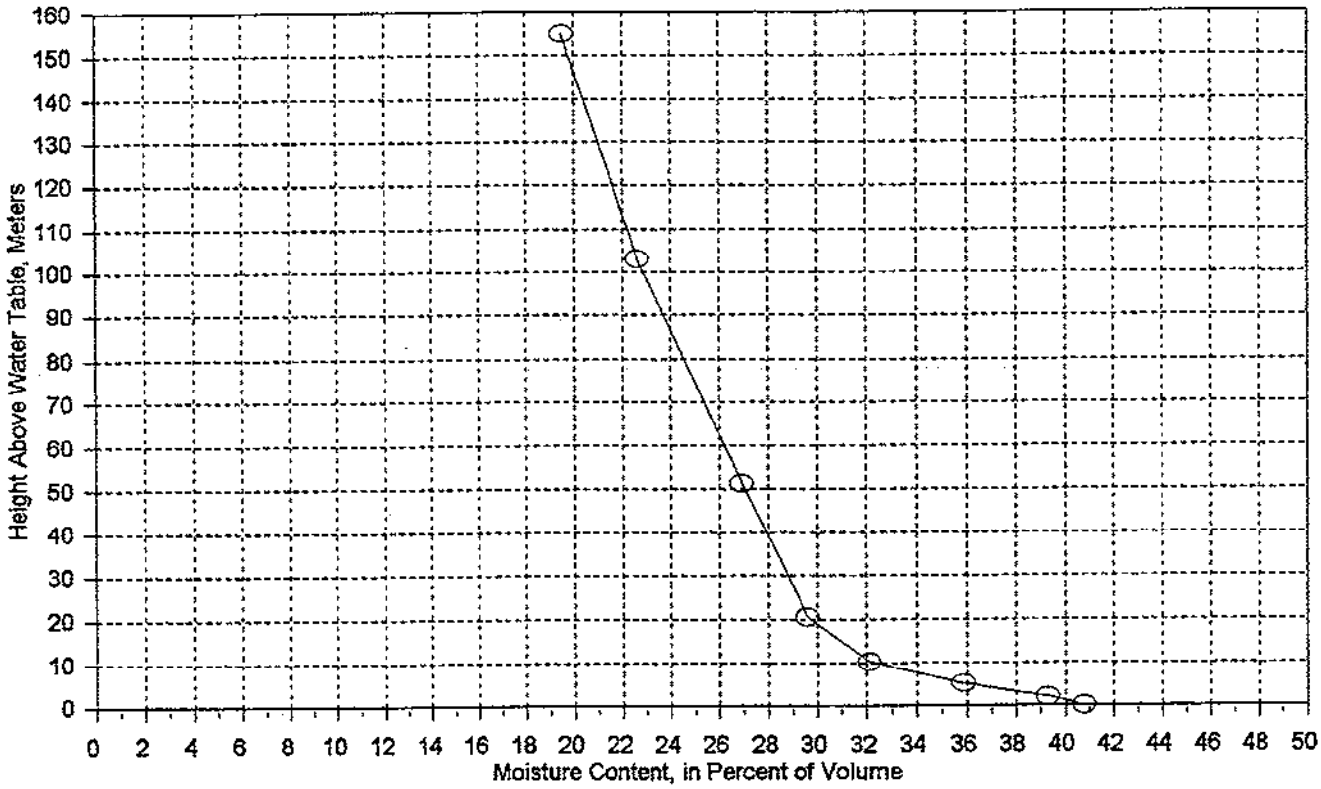

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-4, at 80 % with gravel

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	33.12	36.23	35.92	35.21	34.44	33.92	33.37	32.48	31.84
(5)	5.3	8.41	8.1	7.39	6.62	6.1	5.55	4.66	4.02
(7)	27.82	27.82	27.82	27.82	27.82	27.82	27.82	27.82	27.82
(8)	19.05	30.23	29.12	26.56	23.80	21.93	19.95	16.75	14.45
(9)	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35
(10)	25.73	40.83	39.32	35.88	32.14	29.61	26.94	22.62	19.52

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 22

CAPILLARY-MOISTURE RELATIONS

Sample 18-5, at 80 % Mdd

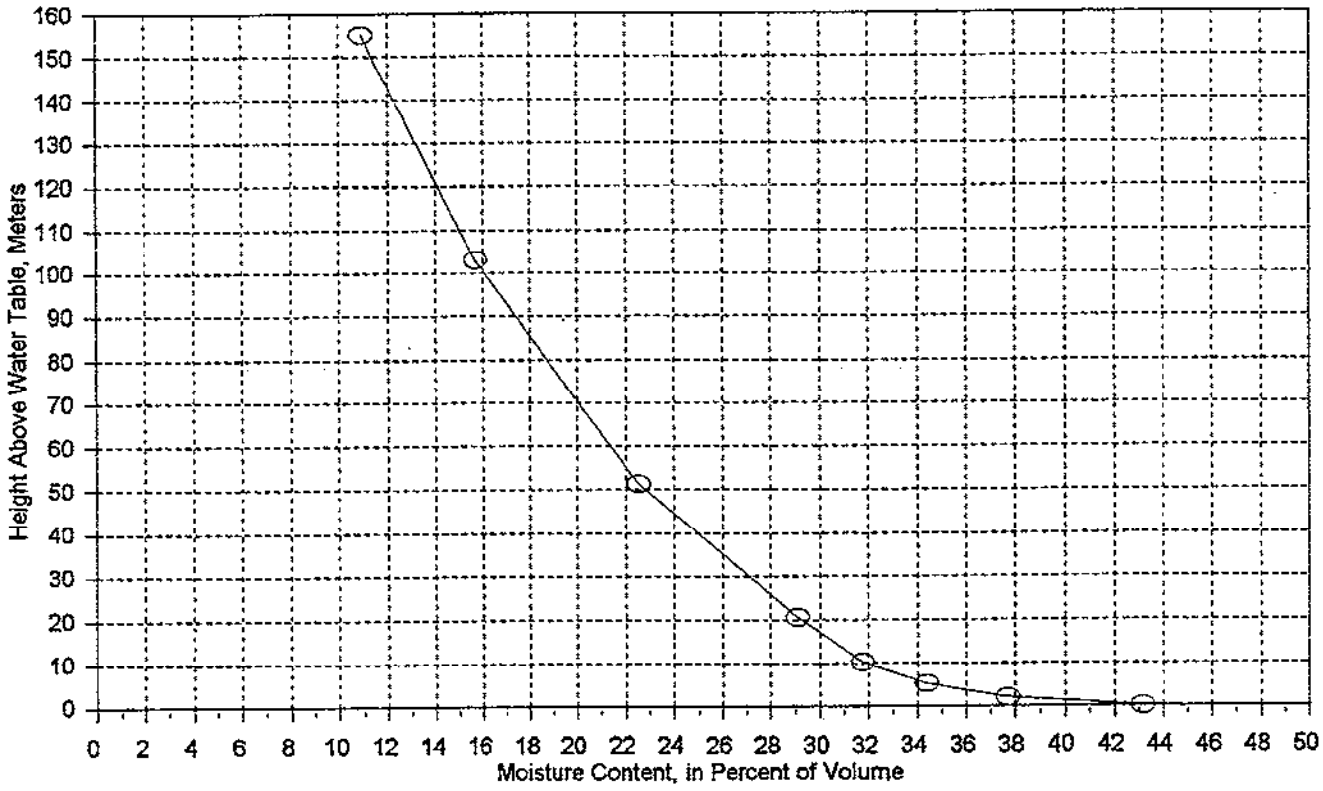

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-5, at 80 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	32.57	36.12	35	34.32	33.78	33.23	31.87	30.46	29.48
(5)	5.34	8.89	7.77	7.09	6.55	6	4.64	3.23	2.25
(7)	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23
(8)	19.61	32.65	28.53	26.04	24.05	22.03	17.04	11.86	8.26
(9)	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
(10)	25.92	43.16	37.72	34.42	31.80	29.13	22.53	15.68	10.92

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 24

CAPILLARY-MOISTURE RELATIONS

Sample 18-5, at 85 % Mdd

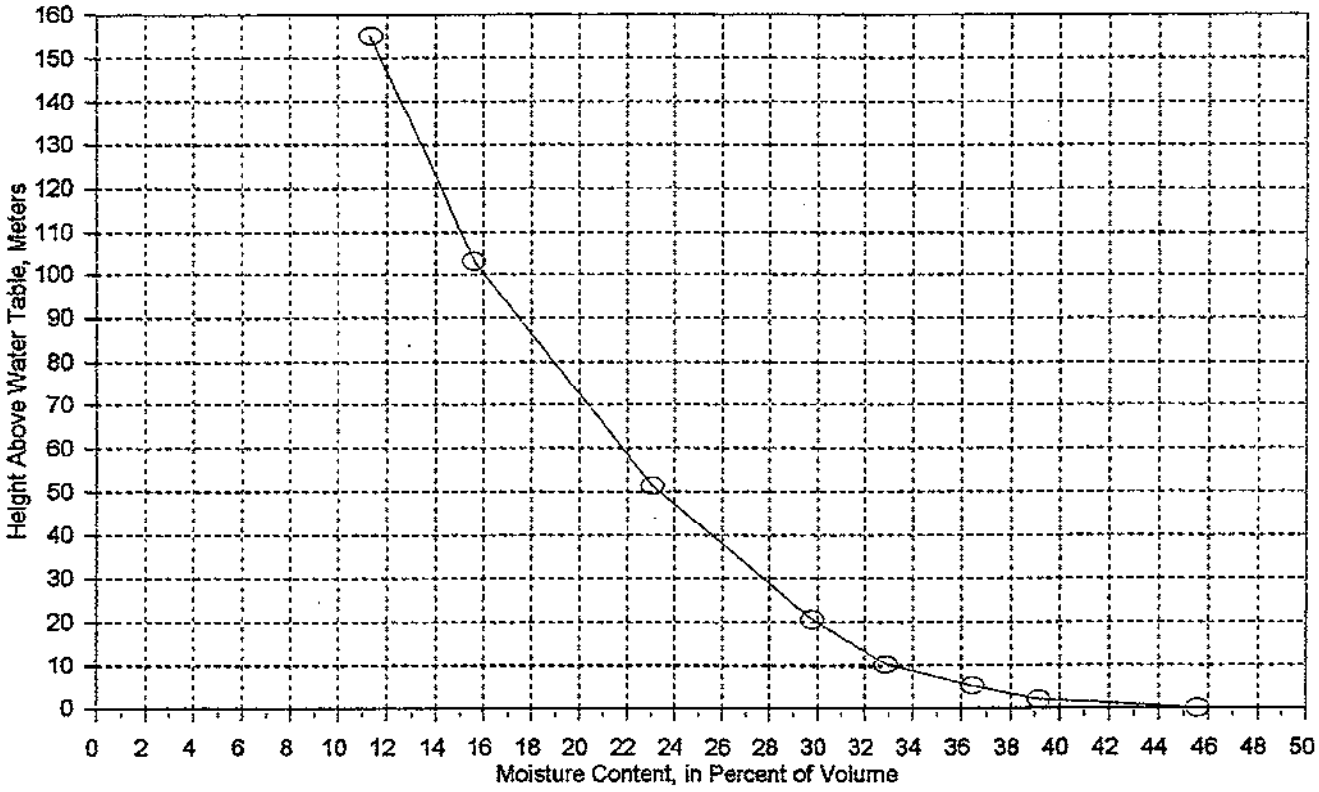

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-5, at 85 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	34.25	38.07	36.75	36.2	35.46	34.82	33.43	31.89	31.02
(5)	5.57	9.39	8.07	7.52	6.78	6.14	4.75	3.21	2.34
(7)	28.68	28.68	28.68	28.68	28.68	28.68	28.68	28.68	28.68
(8)	19.42	32.74	28.14	26.22	23.64	21.41	16.56	11.19	8.16
(9)	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
(10)	27.04	45.59	39.18	36.51	32.92	29.81	23.06	15.58	11.36

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 21

CAPILLARY-MOISTURE RELATIONS

Sample 18-5, at 80 % with gravel

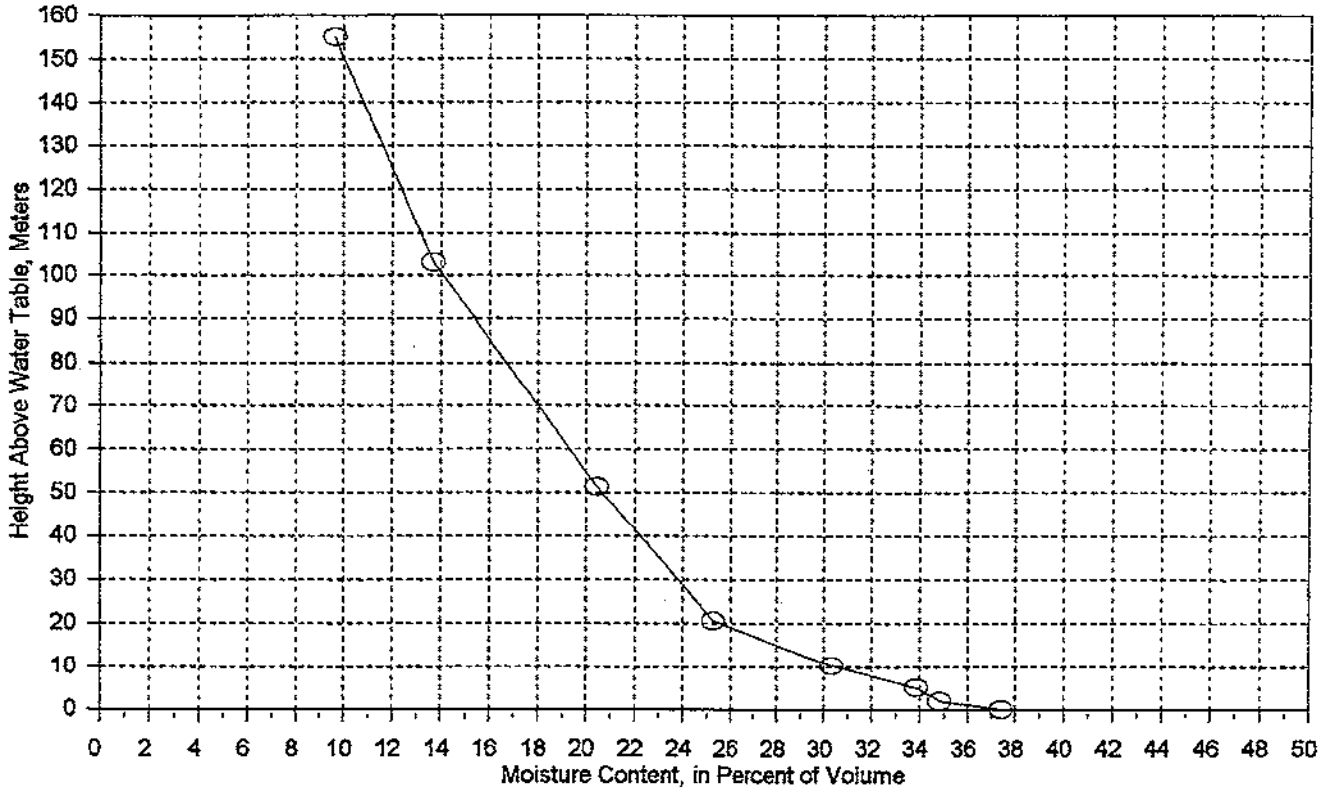

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-5, at 80 % with gravel

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	33.31	37.13	36.6	36.4	35.67	34.63	33.63	32.24	31.41
(5)	3.89	7.71	7.18	6.98	6.25	5.21	4.21	2.82	1.99
(7)	29.42	29.42	29.42	29.42	29.42	29.42	29.42	29.42	29.42
(8)	13.22	26.21	24.41	23.73	21.24	17.71	14.31	9.59	6.76
(9)	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
(10)	18.88	37.43	34.86	33.89	30.34	25.29	20.44	13.69	9.66

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 46

CAPILLARY-MOISTURE RELATIONS

Sample 18-6, at 80 % Mdd

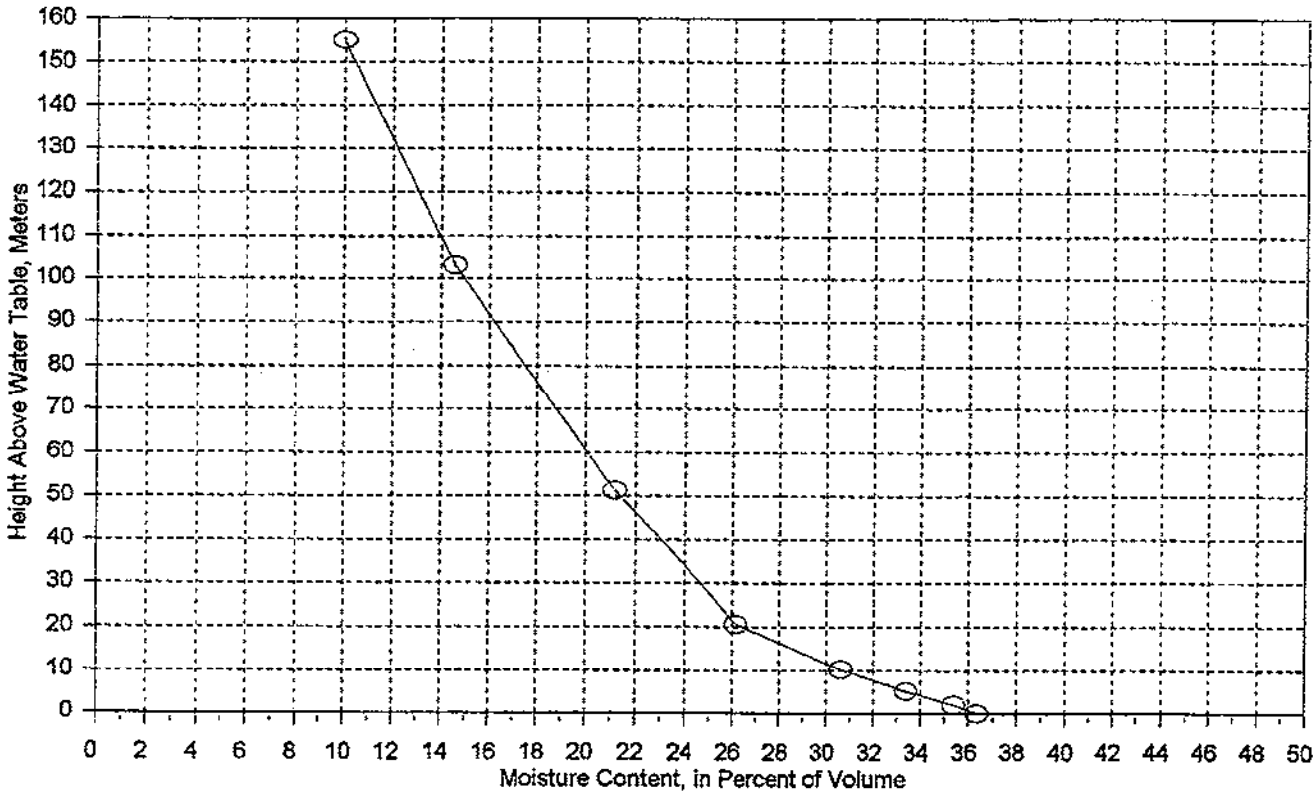

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-6, at 80 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	33.56	37.56	37.36	36.96	36.38	35.46	34.43	33.07	32.13
(5)	3.49	7.49	7.29	6.89	6.31	5.39	4.36	3	2.06
(7)	30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07
(8)	11.61	24.91	24.24	22.91	20.98	17.92	14.50	9.98	6.85
(9)	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46
(10)	16.94	36.36	35.39	33.45	30.63	26.17	21.17	14.56	10.00

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 45

CAPILLARY-MOISTURE RELATIONS

Sample 18-6, at 85 % Mdd

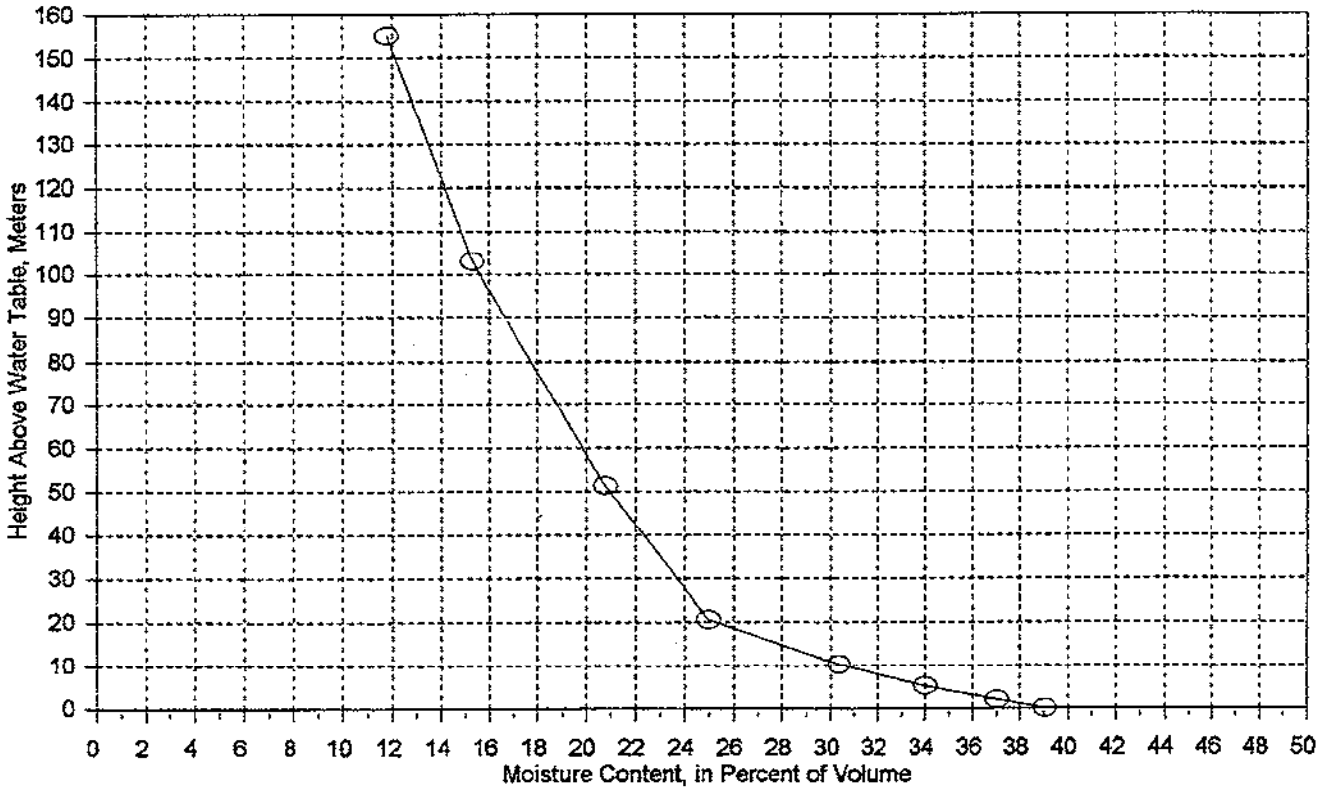

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-6, at 85 % Mdd

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	35.39	39.66	39.24	38.62	37.87	36.76	35.89	34.76	34.04
(5)	3.78	8.05	7.63	7.01	6.26	5.15	4.28	3.15	2.43
(7)	31.61	31.61	31.61	31.61	31.61	31.61	31.61	31.61	31.61
(8)	11.96	25.47	24.14	22.18	19.80	16.29	13.54	9.97	7.69
(9)	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
(10)	18.35	39.08	37.04	34.03	30.39	25.00	20.78	15.29	11.80

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 5

CAPILLARY-MOISTURE RELATIONS

Sample 18-6, at 80 % with gravel

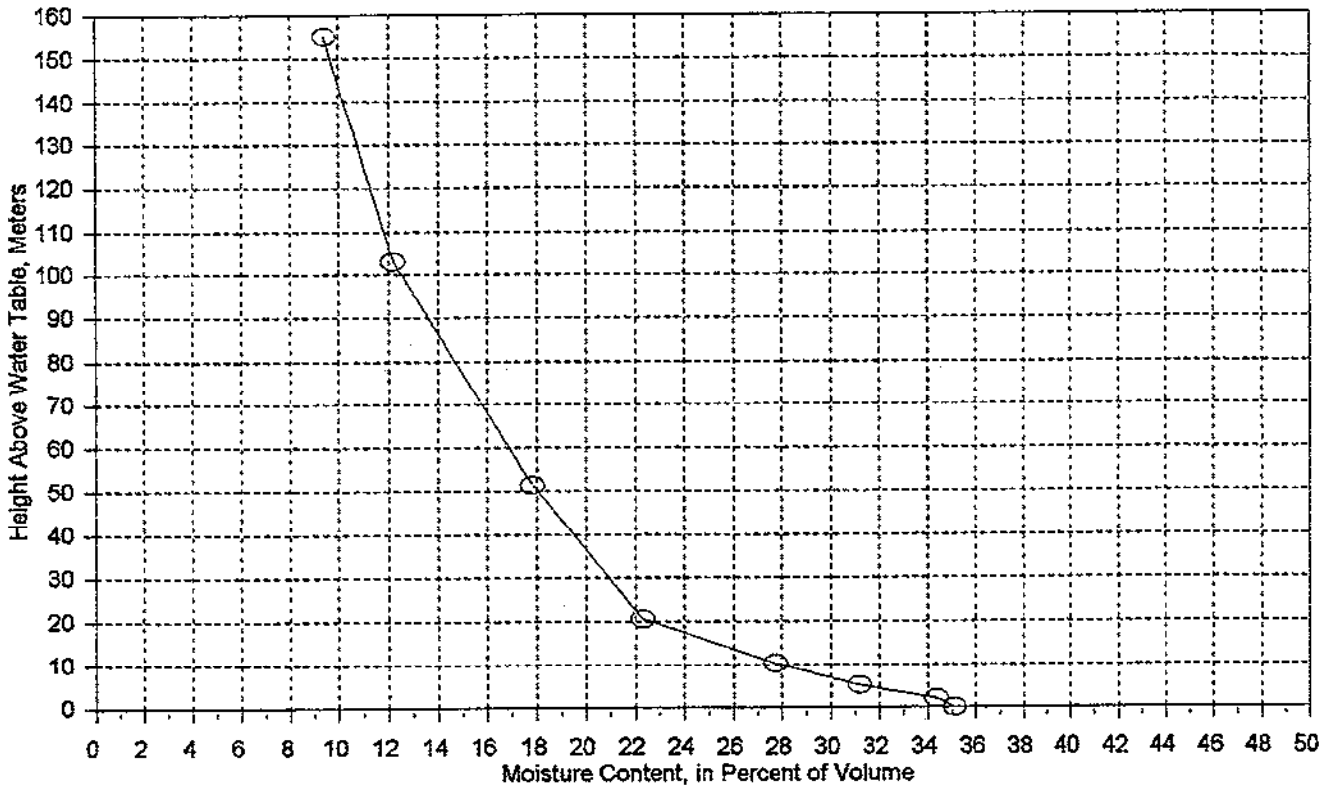

TABLE CAPILLARY-MOISTURE
Strata Inc., FMC Pond Closure
Sample 18-6, at 80 % with gravel

Height m		0	2.06	5.17	10.3	20.6	51.5	103	155
Atm. bar		0	0.2	0.5	1	2	5	10	15
(3)	34.81	39.25	39.1	38.45	37.74	36.61	35.69	34.53	33.96
(5)	2.79	7.23	7.08	6.43	5.72	4.59	3.67	2.51	1.94
(7)	32.02	32.02	32.02	32.02	32.02	32.02	32.02	32.02	32.02
(8)	8.71	22.58	22.11	20.08	17.86	14.33	11.46	7.84	6.06
(9)	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
(10)	13.54	35.10	34.37	31.22	27.77	22.28	17.82	12.19	9.42

KEY:
( ) Refer to ASTM D 3152
(3) Weight of wet sample, g
(5) Weight of moisture, g
(7) Weight of dry sample,g
(8) Moisture content (5/7*100)
(9) Unit weight of dry sample, g/cc
(10) Moisture content volume percent (8*9)
laboratory ref. 28

Appendix C

RCRA Pond Cap Photographs taken June 10, 2009

Pond 8S Cap looking from the Southeast. (6-10-09)

Pond 8S from the Southwest. (6-10-09)

Pond 8S showing vegetative cover. (6-10-09)

Phase IV Ponds (foreground) and Pond 15S (background). (6-10-09)

Pond 8E (foreground) and Pond 9E (background). (6-10-09)

FMC Idaho LLC, Pocatello, Idaho

Groundwater Model Report for the FMC Plant Operable Unit

July 2010

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LIST OF ACRONYMS

amsl	above mean sea level
AFLB	American Falls Lake Beds (regional aquitard in the Michaud Flats groundwater system)
bgs	below ground surface
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cfs	cubic feet per second
DEQ	Idaho Department of Environmental Quality
EPA	United States Environmental Protection Agency
EMF	Eastern Michaud Flats Superfund Site
g/cm^3	grams per cubic centimeter
GMS	Groundwater Modeling System
GWCCR	Groundwater Current Conditions Report (for the FMC Plant OU)
gpm	gallons per minute
l	liter
LTM	long-term monitoring
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
NPL	National Priorities List
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RMSE	root mean squared error
ROD	Record of Decision
SBT	Shoshone-Bannock Tribes
SFS	Supplemental Feasibility Study
SRI	Supplemental Remedial Investigation
WMU	Waste Management Unit

1.0 INTRODUCTION

This report documents the methodology, assumptions, limitations, results, and conclusions for a groundwater flow and contaminant transport model constructed for the FMC Plant Operable Unit (OU) of the Eastern Michaud Flats (EMF) Superfund Site in Pocatello, Idaho. The model was developed as a tool to support the detailed evaluation and comparative analysis of groundwater remedial alternatives in the Supplemental Feasibility Study (SFS) for the FMC Plant OU. The four groundwater remedial alternatives presented and described in detail in the SFS report are:

- **Alternative 0** No action;
- **Alternative 1** Source controls, institutional controls and long-term monitoring (LTM);
- **Alternative 2** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, and A) discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation / evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.
- **Alternative 3** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, groundwater extraction at specific source areas, and A) on-site treatment and discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation/evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

For modeling purposes, no predictive simulation was performed for SFS groundwater Alternative 0 (no action) because this alternative does not meet any of the groundwater Remedial Action Alternatives (RAOs) identified in the SFS. Alternatives 0 and 1 (no action and source controls/LTM) are similar in that no groundwater extraction is included such that the predictive simulation would also be similar; however, the Alternative 1 simulation includes the predicted infiltration reduction for identified and potential source

areas consistent with SFS soil (source control) remedial Alternative 2. Therefore, three predictive simulations (for Alternatives 1, 2, and 3) were performed to evaluate and compare the performance and effectiveness of the alternatives and estimate time to achieve the groundwater restoration RAO.

As described in detail in this report, the groundwater model was constructed and predictive simulations were performed in four general steps as follows:

1. The three-dimensional groundwater flow model was developed and refined during calibration to provide the underlying flow regime for contaminant fate and transport simulations;

2. The contaminant transport model was developed for the site related groundwater constituents arsenic, total phosphorus / orthophosphate, and potassium and refined during calibration (plume matching) to improve estimates of transport parameters;

3. The modeled groundwater remedial alternatives 2 and 3 extraction well configurations and pumping rates were developed and refined to meet appropriate capture and well drawdown criteria; and,

4. The predictive simulations were performed for Alternatives 1, 2 and 3.

The site-specific data utilized to develop the groundwater model include:

- Geologic data from 103 FMC borings and 57 Simplot borings distributed throughout the model domain but primarily focused within the plant site areas and along flowpaths to the Portneuf River.

- Pump test and slug test results and calculated hydraulic conductivity / transmissivity from 45 shallow zone monitoring wells, 19 deep zone monitoring wells and 16 deep zone production wells distributed throughout the model domain but primarily focused within the plant site areas and along flowpaths to the Portneuf River.

- Precipitation data for the period 1917 to 2008 collected at the Pocatello airport (located within 2 miles of the plant sites), Simplot's estimated recharge rate for the gypsum stack, and Simplot's reported (metered) groundwater production and extraction well pumping rates.

- Portneuf River and associated spring flow data from USGS river gauge stations (1990-2009), EMF RI measurements (1992-1994), IDEQ flow measurements (2000-2002) and data and estimates contained in Simplot's remedial design documents (2008).

- Average 2008 groundwater elevations from 82 FMC monitoring wells, 78 Simplot monitoring wells and surface water elevations at Swanson Road Spring (aka the Spring at Batiste Road) and Batiste Spring for calibration of the groundwater flow model.

- Groundwater quality data, specifically for the modeled parameters arsenic, total phosphorus and potassium from 86 FMC monitoring wells, 33 Simplot monitoring wells and Batiste and Swanson Road Spring for 1994 (initial conditions year for transport model plume matching) and 82 FMC monitoring wells, 58 Simplot monitoring wells and Batiste and Swanson Road Spring for 2008 (plume matching year and base year for the predictive simulations).

- Saturated hydraulic conductivity, moisture content, dry unit weight and specific gravity laboratory results for unsaturated and saturated soil samples and laboratory analysis of saturated soil and water samples for arsenic and total phosphorus collected from borings located proximal to former Pond 8S. These results were utilized by Bechtel to estimate input parameters, including arsenic and orthophosphate sorption (distribution) coefficients (K_d) for the Pond 8S Solute Transport Study (Bechtel groundwater transport model). The laboratory data estimated and final model K_d values used by Bechtel in their groundwater transport model were reviewed along with published literature values. The groundwater model transport parameters were then refined from the available site

and published values utilizing 14 years of FMC Plant OU groundwater monitoring data to perform plume matching as described in Section 2.4.5.

Sensitivity analyses were performed for the groundwater flow model, contaminant transport model, and predictive simulations at each step in the project.

Over the course of the FMC groundwater model project, FMC convened five meetings with EPA, the Idaho Department of Environmental Quality (DEQ), and the Shoshone-Bannock Tribes (SBT) to engage the agencies in the planning, development, and preliminary results of the model at each of the steps described above. This series of meetings is summarized below and the full meeting documentation (agendas, meeting presentations, minutes, and follow-up materials circulated in response to agency comments / questions) is included as Appendix A. The five meetings were as follows:

- May 21, 2009 — Conceptual FMC groundwater remedial alternatives; and overview / plan to construct groundwater flow and transport model to support SFS evaluations.
- July 1, 2009 — Summary of site geology, hydrogeology and nature and extent of site-impacted groundwater; flow model construction and calibration; transport model planning and review of conceptual groundwater remedial alternatives.
- August 17-18, 2009 — FMC site tour; review flow model and final calibration results; transport model input parameters and preliminary calibration / plume matching; planning (inputs) for predictive simulations, and preliminary particle tracking results for conceptual remedial alternatives.
- September 21, 2009 — Review groundwater flow model refinement and final calibration results; review calibrated transport model input parameters, plume matching / calibration and

sensitivity analysis; review inputs for predictive simulations and refined remedial alternatives particle tracking results.

- October 21, 2009 — Calibrated groundwater flow and contaminant transport model review; particle tracking results for refined remedial alternatives; predictive contaminant transport simulations and path forward for preparation of groundwater model report.

The final calibrated groundwater flow and transport model and predictive simulations of remedial alternatives (e.g., refinement of the groundwater remedial alternatives such as extraction well locations and flow rates; assumptions regarding the J.R. Simplot Plant OU sources and sinks) were modified based on agency feedback and guidance obtained during these meetings.

1.1 SITE BACKGROUND

This section provides a condensed background, history and summary of previous investigations for the FMC Plant OU. The underlying reference documents cited in this section should be consulted for greater detail.

1.1.1 Location and Setting

The FMC Plant OU is a part of the larger EMF Superfund Site, and is located in southeastern Idaho, approximately 2.5 miles northwest of Pocatello, Idaho. The EMF Site was listed on the National Priorities List (NPL) on August 30, 1990. The EMF Site includes two adjacent production facilities, a former FMC Corporation elemental phosphorus processing plant that ceased operation in 2001 and a phosphate fertilizer processing facility operated by the J.R. Simplot Company. The EMF Site encompasses both the FMC and Simplot sites and surrounding areas affected by releases from these facilities (see Figure 1-1).

The FMC Plant Site is south of Highway 30, covers approximately 1,150 acres, and historically contained all of the process operations used for the production of elemental

phosphorus. The FMC Plant Site adjoins the western boundary of the Simplot Don Plant, as shown on Figure 1-1. There are an additional 212 acres owned by FMC located north of Highway 30 (excluding the 9-acre Tesco property) that are also part of the FMC Plant OU. Figure 1-2 shows the FMC Plant OU groundwater monitoring well network, groundwater "areas" described in the *Groundwater Current Conditions Report* (GWCCR) *for the FMC Plant Operable Unit* (MWH, 2009b) and the FMC Plant Site features (e.g., former ponds) and Remediation Units (RUs) as delineated in the *Supplemental Remedial Investigation* (SRI) *Report for the FMC Plant Operable Unit* (MWH, 2009a)

The EMF study area is located at the base of the northern slope of the Bannock Range, where it merges with the Snake River Plain. The northern part of the EMF study area is located at the southeastern edge of Michaud Flats. The southern part extends onto the north slope of the Bannock Range. The stratigraphy of the study area can be generally described as discontinuous layers of unconsolidated sediments deposited on an erosional surface that was incised in volcanic bedrock. The sedimentary unit immediately above the bedrock is primarily gravel derived from volcanic rocks. A far more detailed description of the physiographic and geologic setting is presented in the EMF Remedial Investigation (RI) Report (Bechtel, 1996) and the GWCCR (MWH, 2009b). The site hydrogeology is summarized in Section 1.2.1 below.

1.1.2 Site History and Previous Investigations Summary

The FMC facility commenced operation in 1949, producing elemental phosphorus from phosphate-bearing shale ore that was mined regionally. The FMC facility permanently ceased production in December 2001. From 2002 through 2006, the facility process operations were decommissioned and the facility infrastructure was demolished to ground level. The RCRA closures of all waste management units (WMUs), including construction of cover systems (caps) on the RCRA surface impoundments (e.g.,Ponds 8S, 9E and 8E, the Phase IV Ponds, Ponds 15S, 16S, 17 and 18 Cell A; see Figure 1-2), was completed by 2005 pursuant to the respective EPA-approved RCRA Closure Plans. The WMUs subject to the RCRA post-closure requirements are currently monitored, including groundwater monitoring, and maintained under their respective RCRA post-

closure plans. Some of the lined and capped RCRA ponds (i.e., Pond 15S and Phase IV Ponds) were installed over top of older unlined ponds (i.e., the old phossy ponds - Ponds 3E - 6E). The remedial action at the calciner ponds (immediately adjacent to the joint fenceline with Simplot; see Figure 1-2), including construction of the final covers (caps), was completed in 2005 pursuant to the DEQ-approved Calciner Pond Remedial Action Plan (FMC, 2003) and IDEQ-FMC Consent Order for remediation of the calciner ponds. The calciner ponds are currently monitored, including groundwater monitoring, and maintained under the Calciner Pond Remedial Action Plan post-remedial monitoring and maintenance plan.

The *EMF RI Report* (Bechtel, 1996), *Remedial Investigation Update Memorandum for the FMC Plant OU* (Bechtel, 2005) and the SRI (MWH, 2009a) present the results of extensive sampling and analysis of the feedstocks, byproducts, co-products, waste materials, and fill materials at the FMC Plant Site. These reports also present the results of extensive surface and subsurface soil sampling and analysis that has been performed at the FMC Plant Site. The GWCCR (MWH, 2009b) provides a summary of the extensive groundwater investigations undertaken during the RI (Bechtel, 1996) and presents a comprehensive update of the groundwater studies and monitoring performed at the FMC Plant OU subsequent to the EMF RI up through FMC's May 2008 groundwater monitoring event. The information and data from these previous investigations utilized to construct the groundwater flow and transport model are summarized in Section 1.2 below.

1.2 SITE CONCEPTUAL MODEL

1.2.1 Hydrogeology

This section presents the geology and hydrogeology of the FMC Plant OU. For greater detail see the EMF RI Report (Bechtel, 1996) and the GWCCR (MWH, 2009b). For reader convenience, the EMF RI Report tables and figures referenced in the following text sections are provided in Appendix B of this report.

Regional Hydrogeologic Setting. The EMF Site is located at the southern margin of the Eastern Snake River Plain which is underlain by basalt and gravel aquifers that are

recharged mostly by underflow from surrounding mountain ranges. Some recharge occurs as irrigation return and deep percolation from precipitation. Several rivers flow onto the Snake River Plain, where surface water infiltrates and ultimately discharges to the Snake River. Groundwater flow through the basalts of the Snake River Plain occurs primarily in thin interflow zones: thin gravel and fracture zones between basalt flows and in the fracture of the basalts (some of the basalts are columnar basalts, with a large interconnected fracture network). Regionally, the Snake River defines the base level for other smaller rivers such as the Blackfoot and Portneuf Rivers. The Portneuf River drains approximately 1,250 square miles, flowing across the Eastern Michaud Flats to the American Falls Reservoir, where it joins the Snake River.

The Michaud Flats are underlain by the same prolific basalt and gravel aquifers. These aquifers are recharged by underflow from the adjoining Bannock and Pocatello mountain ranges and from significant down-valley underflow from the Pocatello Valley aquifer. Smaller drainages also provide underflow to the aquifers (see EMF RI Figure 3.3-2, provided in Appendix B of this report). Direct infiltration from precipitation and irrigation return are other recharge sources. Within the mountainous areas, there are no regionally continuous hydrostratigraphic units. At the transition between mountainous areas and flatlands, there are alluvial fan deposits where groundwater flow occurs primarily within sand and gravel lenses.

Within the Michaud Flats, the aquifer system can be divided into a shallow aquifer and a deeper aquifer. The shallow aquifer is the Michaud Gravel which is typically overlain by a silt aquitard that is generally saturated from 10 to 30 feet above the gravel, but is locally unconfined. The deeper aquifer is comprised of the gravel and volcanics of the Sunbeam and Starlight Formations, and the Big Hole Basalt. The deeper aquifer is the primary water-producing aquifer within the Michaud Flats. The deeper aquifer underlies the American Falls Lake Beds (AFLB), the regional aquitard between the shallow and deeper aquifers (Houser, 1992). Groundwater flow within the regional aquifer system discharges to the Portneuf River (via springs and base flow contribution), American Falls Reservoir, or to one of the numerous springs and seeps in the Fort Hall Bottoms. Groundwater discharges to the Portneuf River along the reach from I-86 downstream to the American Falls Reservoir. The river gains significant flow along this reach as

groundwater discharges through the riverbed and springs on both the east and west sides of the channel. The Pocatello sewer treatment plant (STP) contributes some flow along this river reach.

EMF Site Hydrogeology. The EMF Site hydrostratigraphic framework is generally consistent with the regional framework. Three distinct hydrogeologic areas were delineated in the vicinity of the EMF facilities on the basis of lithologic data, stratigraphic relationships, groundwater flow characteristics, and water chemistry. These areas are the Michaud Flats, Bannock Range, and Portneuf River (see EMF RI Figure 3.3-3, in Appendix B). Within the Bannock Range area there were no continuous hydrostratigraphic units delineated during the RI. Starlight Formation volcanic flows and interflow units are not correlative, and the overall distribution of rock types and saturated materials is best described as highly heterogeneous.

The transition zone between the Bannock Range hydrogeologic area and the Michaud Flats is characterized by small coalescing alluvial fans that are also relatively heterogeneous. In the Michaud Flats, distinct shallow aquifer and deeper aquifer zones were identified in the RI (see EMF RI Figure 3.3-4, in Appendix B). The shallow aquifer is a 10 to 20-feet thick gravel and sand aquifer that is locally overlain by a silt aquitard (EMF RI Figure 3.3-5, in Appendix B). The deeper aquifer is the gravel unit of the Sunbeam Formation and the underlying basalt and rhyolite. The unconsolidated gravel and the underlying volcanic lithologies do not appear to have a large permeability contrast, nor is there an intervening aquitard between these units. Therefore, both units constitute the deeper aquifer in the Michaud Flats area.

The American Falls Lake Beds (AFLB) form an aquitard that separates the shallow and deeper aquifers within the Michaud Flats area. These lacustrine clays and silts have very low permeability and are regionally extensive, extending from the Bannock Range area to the American Falls Reservoir, where they crop out along the reservoir embankment. The AFLB are not present along part of the Portneuf River in the area of Batiste Springs and Wells 524/525 south to Well 520 (see EMF RI Figure 3.3-6, in Appendix B). The Bonneville Flood may have scoured the AFLB, consistent with Trimble's (1976) map of boulder deposition patterns that indicate a main flood channel in this area. Elevation

contours on the top of the AFLB suggest a slight dip to the north. Just to the south of I-86, there is an elongated, east-west depression in the AFLB surface, which may also be an erosional feature of the flood (see EMF RI Figure 3.3-6, in Appendix B).

In areas immediately adjacent to the Portneuf River where the AFLB are not present (as discussed above) and in the Bannock Range area, distinct shallow and deeper aquifers cannot be delineated. In the Bannock Range and Portneuf River areas, the monitoring wells in well pairs were classified as shallow and deep without respect to specific hydrostratigraphic units.

Aquifer Test Results. EMF Site pumping test and slug test results are detailed in Section 3.3.2.1 of the EMF RI Report (see EMF RI Table 3.3-1 Hydraulic Conductivities and Transmissivities of EMF Aquifer System, provided in Appendix B) and are summarized below.

In the Bannock Range area, hydraulic conductivity typically ranges from 0.00001 centimeter per sec (cm/s; 0.03 feet per day [ft/day]) to 0.1 cm/s (280 ft/day) in shallow and deeper zones. Although the lithology is highly heterogeneous, the hydraulic conductivity is fairly consistent throughout much of this area as defined by Wells 142, 300, 301, 304, 306, 323, 325, PEI-2, and PEI-5. Hydraulic conductivities are higher at Wells 307, 308, and 333, which are located along the joint fenceline of Simplot and FMC. The higher hydraulic conductivities in this area are associated with a small, narrow, and deep relict sediment-filled stream channel originating within the Bannock Range (see EMF RI Figures 3.3-2 and 3.3-7A, in Appendix B).

Measured hydraulic conductivity values in the Michaud Flats shallow aquifer range from 0.01 cm/s (28 ft/day) to 0.36 cm/s (1,000 ft/day). The highest values were at Wells 150 (near Pond 8S) and 153 (near Pond 16S). Slightly lower values were associated with the depression in the AFLB, and two of the lowest values were measured in Wells 515 and 516, north of this depression. In the deeper aquifer hydraulic conductivities appear to have an increasing trend to the north. Relatively low values were measured in deeper Wells 103 and 107 with slightly higher values at Well 500 and 133.

Transmissivity data from Jacobson (1984) indicate very high hydraulic conductivities in the deeper aquifer throughout the area north of I-86 (see EMF RI Table 3.3-1, in Appendix B). South of I-86, a transmissivity of 227,000 square feet per day (ft^2/day) was calculated at Simplot production well SWP-7. When SWP-5 was installed and developed, 3 feet of drawdown was measured after 48 hours of pumping at 4,100 gpm, indicating it has a higher transmissivity than SWP-7. Irrigation wells tested in the Michaud Flats had transmissivities ranging from 21,900 to 444,000 ft^2/day (Jacobson, 1984).

The bouldery gravel aquifer in the Portneuf River area has the highest hydraulic conductivity in the area. Calculated values ranged from 0.01 cm/s (28 ft/day) to 1.7 cm/s (4,800 ft/day). Most of the slug test results from the Portneuf River area indicate hydraulic conductivities are greater than 0.36 cm/s (1,000 ft/day). Hydraulic conductivities appear to be similar in the shallow and deeper wells throughout the Portneuf River area.

Groundwater Elevations, Flow Patterns, and Vertical Gradients. Depth to groundwater in EMF Site wells ranges from over 150 feet in the Bannock Range to less than 10 feet near the Portneuf River (groundwater reaches the ground surface at the springs). The groundwater elevations in the Bannock Range were up to 4,629 feet amsl (above mean sea level), as measured in PEI-1. Approximately 8,500 feet north the groundwater elevations were 4,383 feet amsl at Batiste Spring along the Portneuf River (see EMF RI Figure 3.3-8F, in Appendix B).

There are seasonal water level fluctuations in the Michaud Flats, typically on the order of 2 to 4 feet, which may be associated with irrigation withdrawal and recharge patterns. Overall, the water levels indicate no long-term decrease in water levels at the site. Water levels in the shallow and deep wells have typically fluctuated within 4 to 8 feet between maximum and minimum measured levels over the 15 to 18 year period of monitoring for most of the wells. Maximum water levels were generally observed in the mid- to late 1990s during a cycle of average and above average regional precipitation during the monitoring period for most wells. Minimum water levels were typically observed in the 2001 and 2002 period that coincided with several years of significantly below average

precipitation in the region. Water levels have slowly rebounded in recent years but generally have not recovered to levels measured during the 1990s.

Groundwater elevation potentiometric contour plots for the shallow aquifer were prepared for each quarterly sampling event from June 1992 through May 2008. The potentiometric contour map for the shallow aquifer in May 2008 is presented in Figure 1-3. Potentiometric contour maps from June 1992 through May 2008 are provided in Appendix B of the GWCCR (MWH, 2009b). These contour patterns are very consistent from quarter to quarter and year to year. Several key features are evident in the contour patterns.

- There are very steep horizontal hydraulic gradients in the Bannock Range.
- Within the western part of the monitoring network, there is a slight northeast-trending trough in the groundwater surface extending through the area of Wells 170, 168, 139 and 140 (northeast of Pond 15S).
- There is a distinct increase in the horizontal hydraulic gradient in the vicinity of Wells 146 and TW-9S, and a decreasing hydraulic gradient further east, in the vicinity of Wells 517, TW-11S and TW-12S.
- Shallow groundwater contour patterns do not appear to be influenced by production wells pumping from the deeper aquifer nor from the dramatic decrease in pumping from production wells FMC-1 and FMC-3 following plant shutdown in December 2001.

General flow patterns described by the hydraulic head contours indicate that groundwater flows north off the Bannock Range based on the steep hydraulic gradients observed in the low permeability materials. When this Bannock Range flow enters the highly permeable aquifer materials beneath Michaud Flats and the Portneuf River, groundwater flow converges sharply, with all shallow Bannock Range groundwater ultimately discharging along a short reach of the Portneuf River at Batiste Spring, the Spring at Batiste Road (aka Swanson Road Springs), and as bank seeps and baseflow to the river in the reach bounded by these springs just north of I-86.

Horizontal groundwater seepage velocities, calculated from hydraulic conductivities, horizontal gradients, and estimated porosity, are up to 12 ft/day in the Portneuf River area, 0.4 ft/day in the Bannock Range area, and from 1 to 11 ft/day in the Michaud Flats area. The variable seepage velocities calculated in the Michaud Flats area illustrate the effects of variable horizontal gradients and the wide range of hydraulic conductivities calculated for this area (see EMF RI Table 3.3-1, in Appendix B). The consistently high seepage velocities in the Portneuf River area are indicative of the very high hydraulic conductivities associated with the Bonneville Flood deposits.

Vertical head differentials were measured in well pairs installed during the EMF RI and during previous investigations. Vertical head differentials are one measure of the flow potential between shallow and deeper saturated zones (the other factor is the vertical hydraulic conductivity). The vertical head differentials also provide indications of the direction of the flow or gradient between shallow and deeper zones.

The overall pattern of vertical differentials shows that in the area along the flanks of the Bannock Range there is a downward vertical hydraulic gradient. Well pairs 130/137 and 101/102 had persistent downward gradients, and well pair 103/104 had a slight upward gradient (less than 0.10 foot head differential). This pattern is still observed based on the water levels at well pairs 101/102, 130/137 and 103/104 measured during May 2008. Water levels measured in May 2008 for site-wide shallow/deep well pairs are shown on GWCCR Table 2.2-1 (in Appendix B). Further north, vertical gradients were upward in well pairs 134/133, 117/118 (now abandoned), 107/108, TW-5S/TW-5I, and 500/501 during the EMF RI. During the EMF RI, there was a downward gradient measured in well pair 125/126, located near production well FMC-1, which draws water from the deeper aquifer and may have induced a local downward gradient. However, based on measurements in May 2008, the slight (less than 0.1 foot) downward gradient at well pair 125/126 does not relate to pumping of FMC's production well FMC-1, as this well has not been pumped in over eight years.

From the area along the joint facilities' fenceline out to the Portneuf River, there were relatively large upward vertical head differentials measured in the well pairs 309/310, 329(311)/312, 109/110, 319/320, TW-11I/11S, 504/505, 503/519, and 315/316 during the

EMF RI. In these well pairs the water levels in the deeper wells were typically 2 to 6 feet higher than water levels in the shallow wells. The May 2008 water level measurements at well pair 109/110 showed the water level in the deeper well (Well 109) was 4.6 feet higher than the shallow well (Well 110) with a calculated upward vertical gradient of 0.09 feet per foot, consistent with the EMF RI findings in this area of the site.

Summary:

- Hydraulic gradients (and inferred groundwater flow directions) within the EMF study area are very stable and have not changed significantly, as demonstrated by 18 years of quarterly monitoring. A very significant decrease in extraction from the FMC production wells after the plant shutdown in 2001 has had negligible effect on groundwater gradients in the EMF study area.

- Migration of site-related constituents from the shallow groundwater zone to the deeper zone is inhibited by upward vertical hydraulic gradients and the presence of confining strata (silt and clay units of the AFLB) throughout large portions of the EMF study area.

- Northward flow of impacted groundwater from the western ponds area (i.e., Pond 8S and the old phossy ponds including Ponds 3E - 6E, now beneath the RCRA lined and capped ponds Pond 15S and Phase IV Ponds) and central plant areas of the FMC Plant Site is limited to the area south of I-86, due to the effects of converging flow of groundwater from the Michaud aquifer to the west and northwest.

- Virtually all groundwater underflowing the EMF facilities discharges to the Portneuf River at Batiste Spring, the Spring at Batiste Road (aka Swanson Road Springs), and as bank seeps and baseflow to the river in the reach bounded by these springs.

1.2.2 Nature and Extent of Groundwater Contamination

This section presents the nature and extent of EMF-impacted groundwater beneath the FMC Plant OU. For greater detail on the nature and extent of the EMF-impacted groundwater and evaluation of groundwater contaminant source areas at the FMC Plant OU, see the EMF RI Report (Bechtel, 1996) and the GWCCR (MWH, 2009b).

Various constituents in groundwater exceed background levels beneath the FMC Plant OU in areas downgradient from the former unlined phossy ponds in the western ponds area (beneath lined RCRA ponds including Pond 15S and the Phase V ponds), the former kiln scrubber ponds and former kiln scrubber overflow pond, and the former unlined calciner ponds in the eastern portion of the central plant area associated with and the Simplot gypsum stack in the joint-fenceline area. The EMF RI and post-RI CERCLA, RCRA, Calciner Pond Remedial Action groundwater monitoring program results identify the following FMC-related constituents in groundwater:

- Common ions: potassium, chloride, and sulfate;
- Nutrients and fluoride: ammonia, nitrate, total phosphorus / orthophosphate and fluoride;
- Metals: arsenic, boron, manganese, and selenium, and vanadium (only in the eastern central plant and joint fenceline areas); and,
- Other inorganic constituents: total cyanide and elemental phosphorus.

Elemental phosphorus has only been consistently detected in RCRA slag pit sump monitoring wells 108 and 122.

Supplemental sampling events for expanded metals, organic compound, and radionuclide analytical parameters have provided further evidence supporting the findings of the EMF RI that the following constituents are not FMC-related contaminants in groundwater:

- Metals: aluminum, antimony, beryllium, cadmium, copper, lead, molybdenum, mercury, silver, thallium and zinc;

- Organic compounds; and
- Radionuclides.

Supplemental sampling did not indicate that total uranium is an FMC-related constituent in groundwater. Elevated uranium (and gross alpha activity associated with the uranium 238 and 234 isotopes) in joint-fenceline area wells are more likely associated with naturally-occurring uranium in volcanic bedrock units within which these wells are screened.

Figures 1-4 through 1-6 present groundwater concentration maps for arsenic, total phosphorus / orthophosphate, and potassium, respectively, for the FMC Plant OU. These constituents were selected for presentation as they are the primary indicator parameters of EMF-impacted groundwater, based on their prevalence above background concentrations.

The spatial extent of the FMC-related groundwater impacts in 2008 is comparable to that defined during the EMF RI performed in 1994. Concentrations of FMC-related groundwater impacts in the western ponds area, central plant area, and downgradient portions of the joint fenceline / calciner ponds area have decreased (groundwater beneath the FMC Plant Site has improved) and are expected to continue to improve due to dilution, dispersion, and the lack of sustained hydraulic head (e.g., Pond 8S closure, Calciner Ponds area remedial action) on any identified or potential source areas that would result in recharge of contaminated water at the site.

Increasing trends of sulfate, orthophosphate, potassium, and arsenic in wells upgradient of the calciner ponds area (in the joint fenceline area) indicate that the Simplot gypsum stack is contributing increasing levels of these constituents to groundwater upgradient in the joint fenceline area over time. There is consequently a potential for these constituents to increase in concentration over time and potentially reverse the currently stable or decreasing concentration trends in the downgradient portions of the joint fenceline / calciner ponds area (FMC, 2009).

1.2.3 Source Areas

The three most significant source areas: 1) former Pond 8S, 2) former phossy ponds (Ponds 3E through 6E) that are now largely beneath RCRA lined and capped ponds Pond 15S and Phase IV Ponds in the western ponds area of the FMC Plant Site, and 3) the Simplot gypsum stack in the joint fenceline area that needed to be considered during construction and calibration of the groundwater transport model are discussed in greater detail in this section. Section 5.2 of the GWCCR (MWH, 2009b) presents a detailed evaluation of identified and potential source areas of groundwater contaminants at the FMC Plant Site.

Pond 8S. Pond 8S was identified as a likely source of groundwater contamination at the site during the Preliminary Site Characterization Study in 1992. Pond 8S had a surface area of about 3.2 acres when in operation. The pond is unlined and contained both waste water and solids, collectively referred to as "phossy waste." Pond 8S received phossy wastes from 1971 to 1981. Samples of phossy pond influent (phossy wastewater and precipitator slurry) were analyzed for common ions and metals during the EMF RI. The results from these samples (designated “Discharge to Pond 8E,” “Discharge to Phase IV Ponds” and “Phossy Water Discharge to Pond 8S”) are presented in EMF RI Table 4.2.3-3 (see Appendix B). Because the samples were not filtered, the results represent both dissolved-phase and solid-phase constituents. The results for phossy pond wastewater relevant to the groundwater transport model are:

- arsenic concentrations ranged from 0.0486 - 0.1454 milligrams per liter (mg/l),
- total phosphorus concentrations ranged from 1,370 - 7,680 mg/l, and
- potassium concentrations ranged from 2,890 - 9,890 mg/l.

To prevent oxidation (smoking and/or burning) of the phossy solids in the pond, the solids were kept under several feet of water while the pond was in operation and the water cover was maintained on the pond until closure of Pond 8S was initiated in 1994.

Prior to initiating closure of Pond 8S, Bechtel conducted a focused study to support proceeding with closure of the pond. That study is documented in the Pond 8S Solute

Transport Study (Bechtel, 1993) that was submitted with the Pond 8S Closure Plan. The study included sampling and testing of soil samples from the unsaturated zone, the saturated fine-grained zone and underlying shallow saturated coarse-grained zone beneath Pond 8S (the borings were drilled as close as practicable to the edge of the pond). The soil properties testing included moisture content, unit weight, specific gravity, grain size analysis, saturated permeability, and moisture-tension curve of the unsaturated samples. Soil samples from the unsaturated zone and paired soil and groundwater samples from the saturated fine-grained zone and underlying shallow saturated coarse-grained zone were analyzed for arsenic, orthophosphate, and fluoride to estimate sorption coefficients.

Quarterly groundwater monitoring specific to Pond 8S began in 1991 has been performed continuously since that time for the modeled constituents arsenic, orthophosphate / total phosphorus and potassium (in addition to the other monitored parameters). The initial fill and removal of the standing hydraulic head from Pond 8S was completed in 1994. Following placement of the initial fill and temporary cap in 1994, Pond 8S was further dewatered to the extent practicable through a wickdrain and subgrade pumping system over the 1994 through 1996 period. The Pond 8S final cover (cap) was constructed and completed in 1999.

As described in the GWCCR (MWH, 2009b), Wells 155, 156 and 157 downgradient of Pond 8S all show decreasing trends (Mann-Kendall test for trend) for arsenic, orthophosphate / total phosphorus, and potassium for the period 1991 through 2008. Time series graphs for arsenic, total phosphorus / orthophosphate, and potassium and are shown on Figures 1-7 through 1-9. The trends at the Pond 8S wells validate the EMF RI prediction that dewatering and capping would be effective in reducing pond solute and constituent migration to groundwater and a gradual improvement in groundwater quality downgradient from Pond 8S would occur.

Old Phossy Ponds – Ponds 3E, 4E, 5E and 6E. A series of unlined “phossy ponds” (Ponds 3E, 4E, 5E, and 6E) in the western ponds area of the FMC Plant Site were identified as likely historic sources of groundwater contamination at the site during the Preliminary Site Characterization Study in 1992. These ponds were unlined and

contained both waste water and solids, collectively referred to as "phossy waste," similar to the waste discharged to Pond 8S. RCRA lined and capped ponds including Pond 15S and Phase IV Ponds were installed on the old phossy ponds (see Figure 1-2).

High concentrations of arsenic (but not total phosphorus / orthophosphate or potassium) in groundwater are encountered downgradient from former Ponds 3E, 4E, 5E and 6E. The area of highest arsenic impact to groundwater from these former ponds is observed in Wells 115, 166, 168, 131 and 139. Some of these wells are located within the footprint of former Ponds 3E and 5E or are immediately downgradient from these ponds collectively.

The former unlined Ponds 3E, 4E, 5E and 6E were removed from service and dried in 1980 and 1981, and were partially excavated for the construction of the Phase IV Ponds in 1981 and Pond 15S in 1982 (see Appendix M in the EMF RI Report [Bechtel, 1996]). Portions of these former ponds were not covered by the Phase IV ponds and Pond 15S (Figure 1-2). The initial fill, dewatering and temporary cover phase of the RCRA closures of the Phase IV ponds and Pond 15S was completed in 1999 and the final cover and closures were completed in 2004.

As described in greater detail in the GWCCR (MWH, 2009b), the groundwater conditions observed at the wells downgradient from Pond 15S / the Phase IV ponds and the former Ponds 3E, 4E, 5E and 6E are more likely attributable to the former “old phossy” ponds (Ponds 3E - 6E) based, in part, on these lines of evidence:

- The ranges of potassium and total phosphorus / orthophosphate concentrations in the wells downgradient from former Ponds 3E – 6E are not consistent with groundwater impacted by a more recent release (within 10 to 15 years) to groundwater as observed at Pond 8S. Potassium, which is highly soluble and would not be attenuated in the vadose zone by sorption or precipitation, and total phosphorus / orthophosphate concentrations in these wells indicate an attenuated source of these mobile constituents that is “older” than Pond 8S.

- Increasing indicator-parameter concentration trends (arsenic, potassium, and nitrate trends identified with the Mann-Kendall test) in several of the wells

downgradient from the Pond 15S / Phase IV ponds area began after the initial fill, removal of standing hydraulic head and temporary cover installation at Pond 15S and the Phase IV ponds. These trends are inconsistent with the decreasing trends observed following the initial fill, dewatering and temporary cover at Pond 8S that would have been predicted for Pond 15S or the Phase IV ponds if these units had been a source of groundwater impacts. As described above, these trends may be related to infiltration of precipitation and run-on from surrounding areas into the low-lying portions of former Ponds 3E - 6E.

Simplot Source Areas. Because the groundwater model domain encompasses both the FMC and Simplot Plant Sites, information regarding Simplot sources and sinks (pumping) was reviewed as needed to develop input values to construct the flow and transport model. However, as the objective of the groundwater model is the evaluation of groundwater remedial alternatives for the FMC Plant OU, only a cursory review of Simplot groundwater information is provided below.

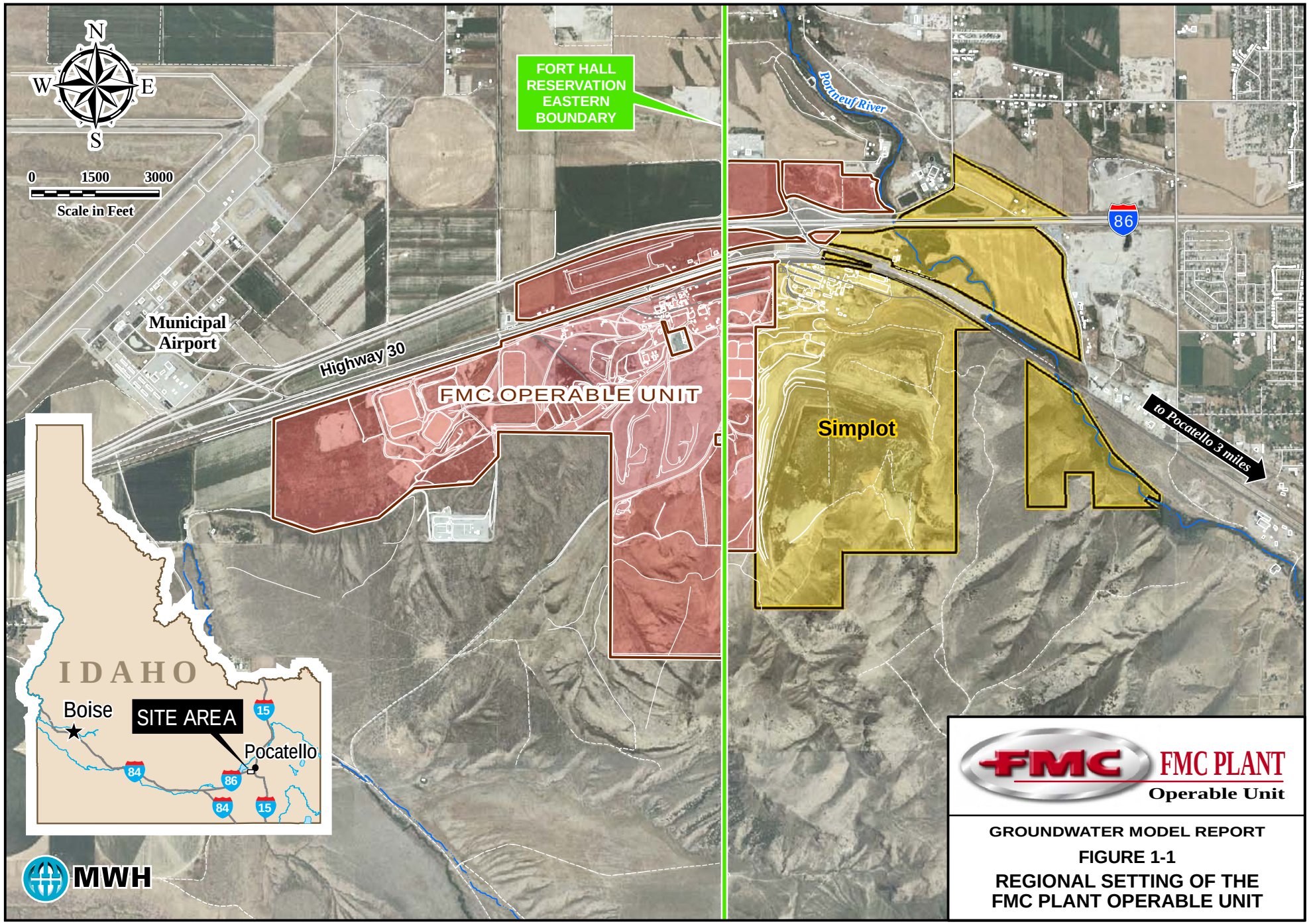
The EMF RI groundwater investigations identified the Simplot gypsum stack and (former) east overflow pond as significant sources of constituents to groundwater. Arsenic and total phosphorus / orthophosphate concentrations were significantly elevated in groundwater impacted by these source areas. As reported in the EMF RI (Bechtel, 1996), Simplot permanently closed the (former) east overflow pond and concentrations of constituents in groundwater related to the east overflow pond (at Well 318) decreased rapidly after the pond was closed.

Since the EMF RI, the gypsum stack has grown larger in volume and has expanded toward the south. Simplot estimates the infiltration rate from the gypsum stack is in the range of 800 to 900 gpm (Newfields, 2008a). Groundwater monitoring data and an evaluation of the gypsum stack influence in the joint fenceline area is presented in the GWCCR (MWH, 2009b) and FMC's Calciner Pond Remedial Action 2008 Annual Groundwater Monitoring Report (FMC, 2009). Subsequent to the EMF RI, a Simplot source(s) within their Phosphoric Acid Plant (PAP) has been identified as a significant source of total phosphorus (and other constituents) to groundwater (Newfields, 2008b).

Simplot's site-wide groundwater monitoring data is presented in their quarterly groundwater monitoring reports, for example the Second Quarter 2008 Groundwater Monitoring Report – Simplot Plant Area (NewFields, 2008a).

Simplot recently prepared a Remedial Action Plan (Simplot, 2009) that, among other actions, includes lining the gypsum stack over a multi-year period with a target completion in 2015.

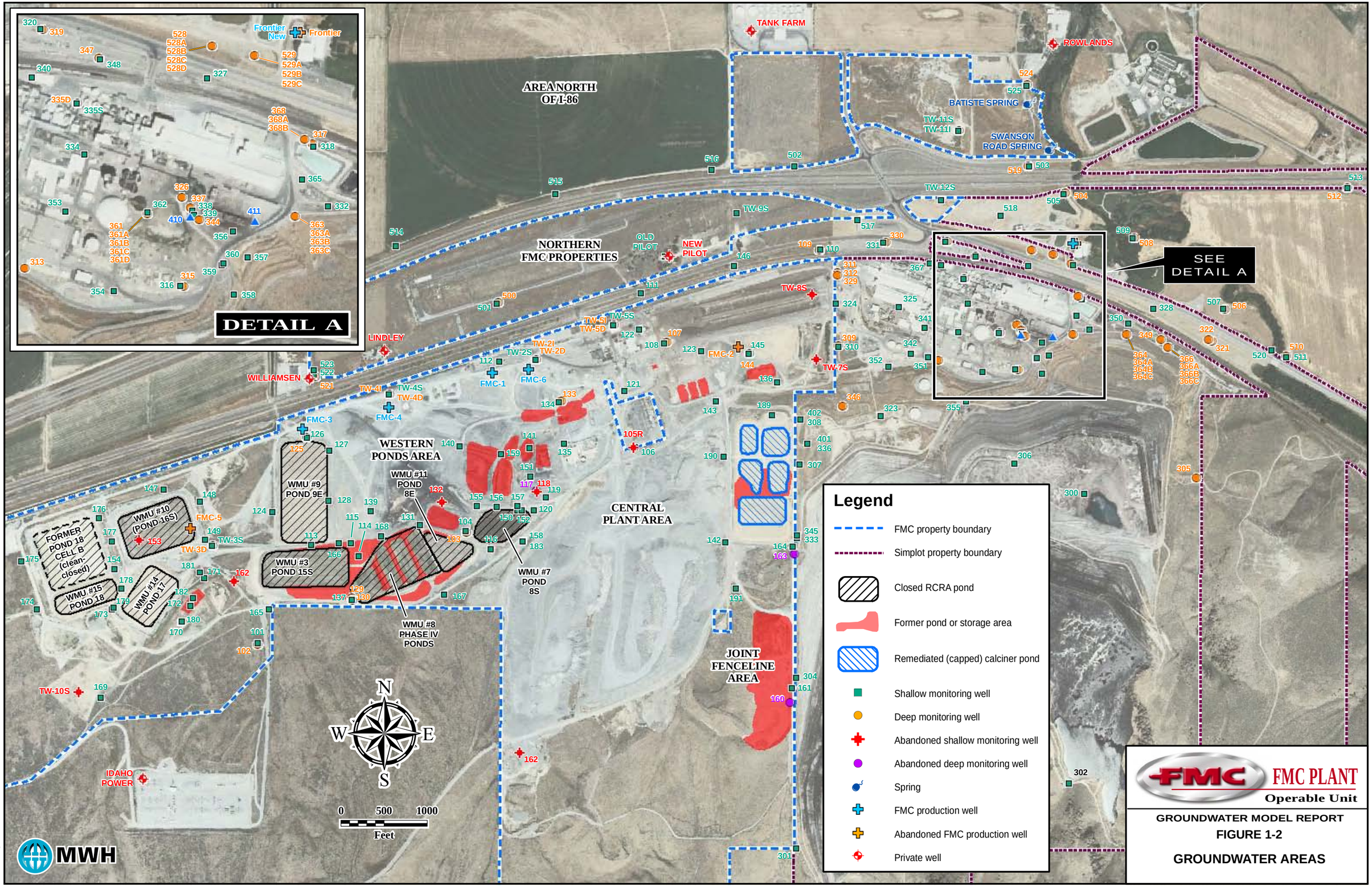
FILE *Fig 1-01 Regional Setting_waerial_1109.mxd* *11/12/09*



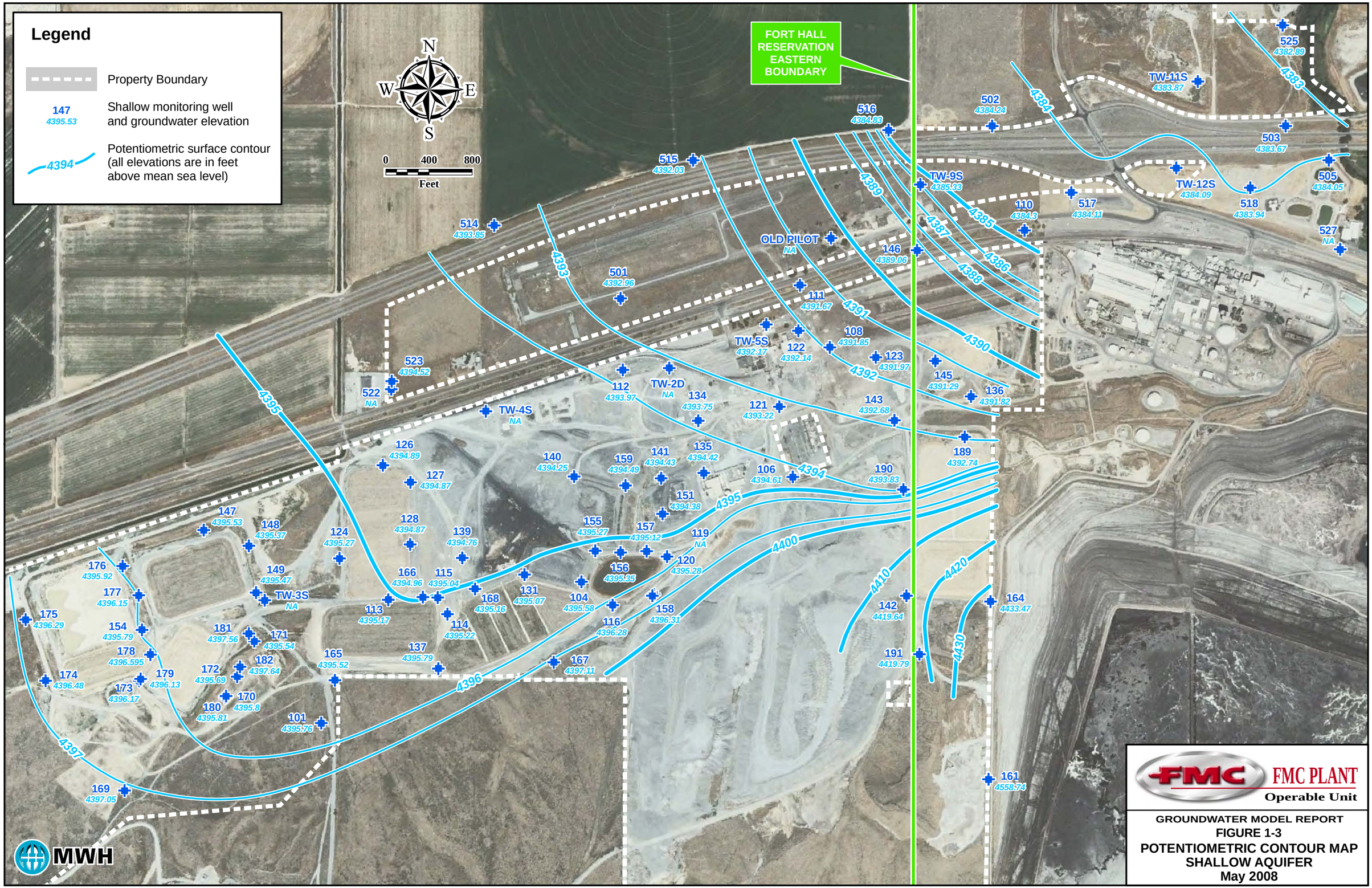
GROUNDWATER MODEL REPORT

FIGURE 1-1

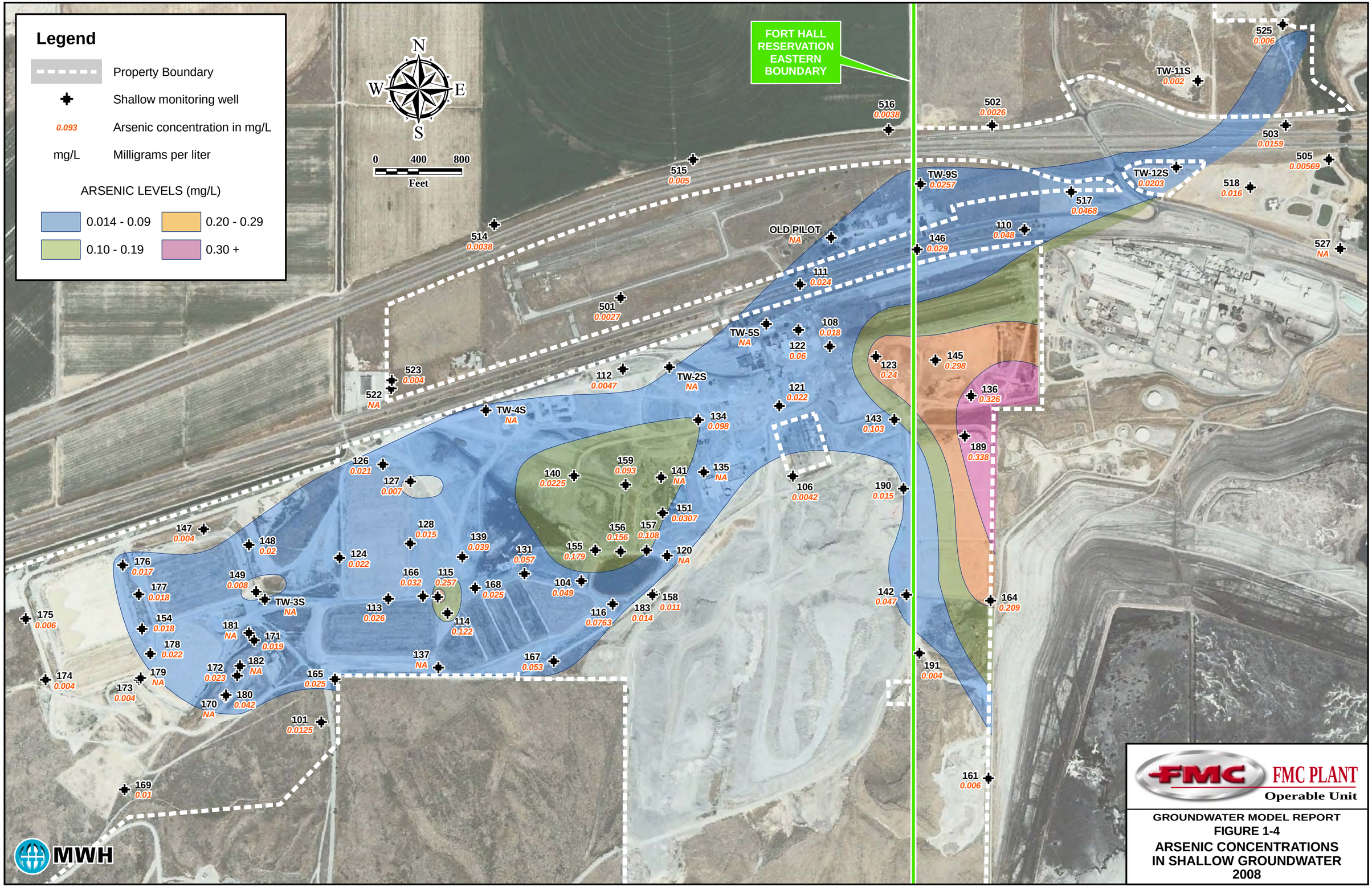
REGIONAL SETTING OF THE FMC PLANT OPERABLE UNIT



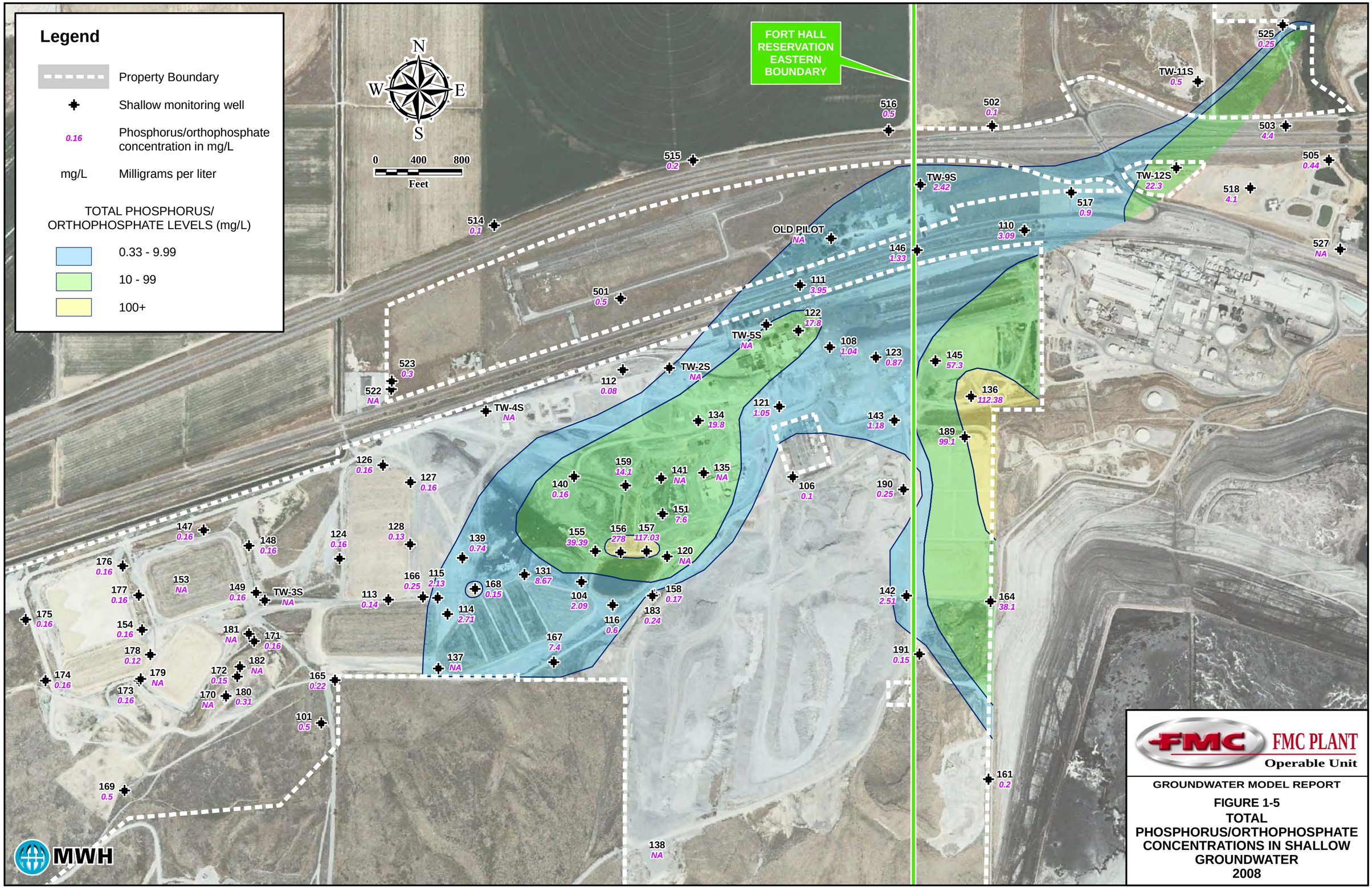
FILE Fig 1-02_GW Areas_0210.mxd 2/15/10



FILE Fig 1-03_GW Contour Map_MAY2008_710.mxd 8Jul10



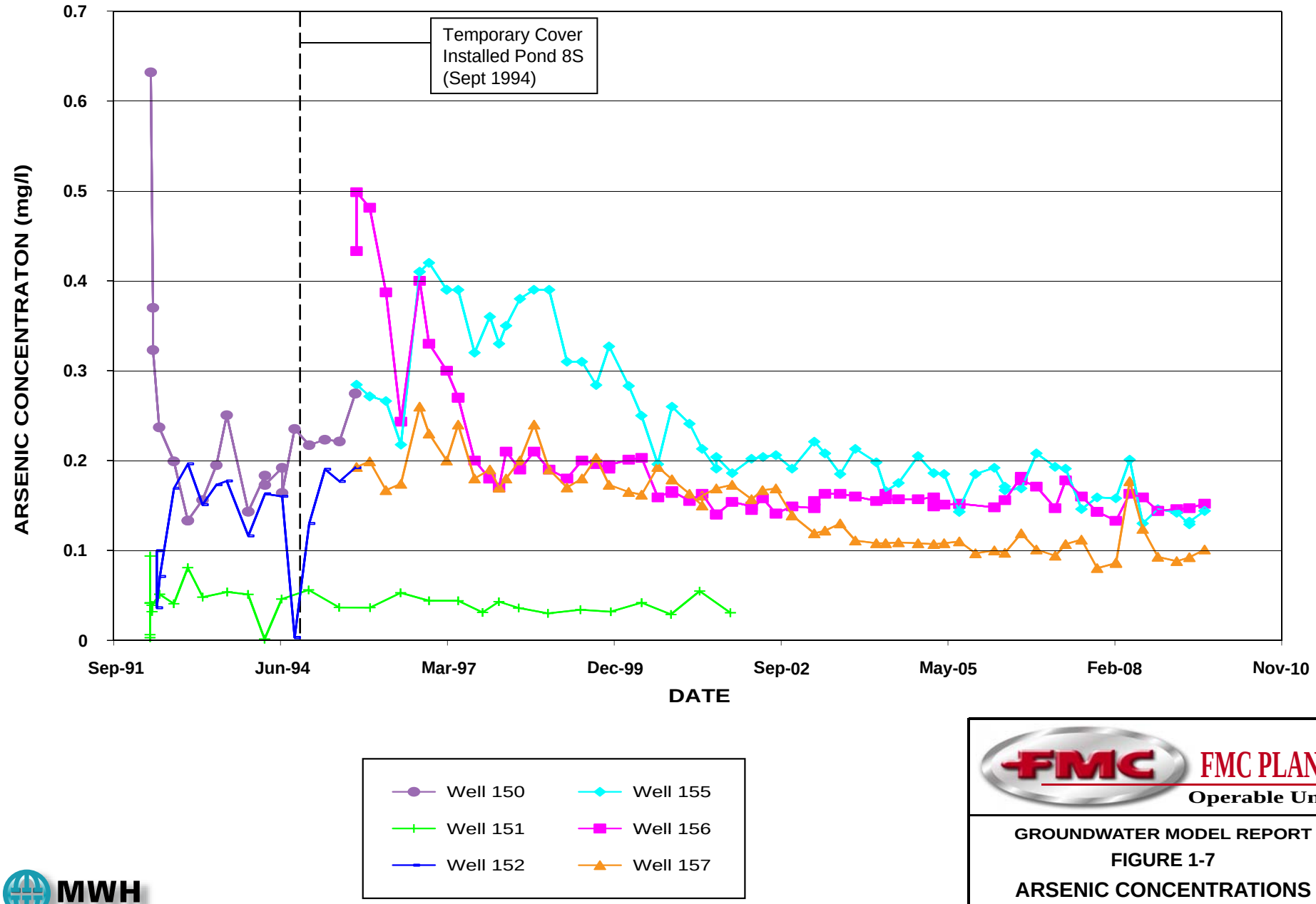
FILE Fig 1-04_Arsenic in Shallow GW_710.mxd 8Jul10



FILE Fig 1-05_Orthophosphate in Shallow GW_0710.mxd 8Jul10

FILE Fig 1-06_Potassium in Shallow GW_0710.mxd 9Jul10

FILE *Fig 1-07_Arsenic Concentrations_Pond 8S Downgradient Wells.ai* *12/17/09*



FMC PLANT
Operable Unit

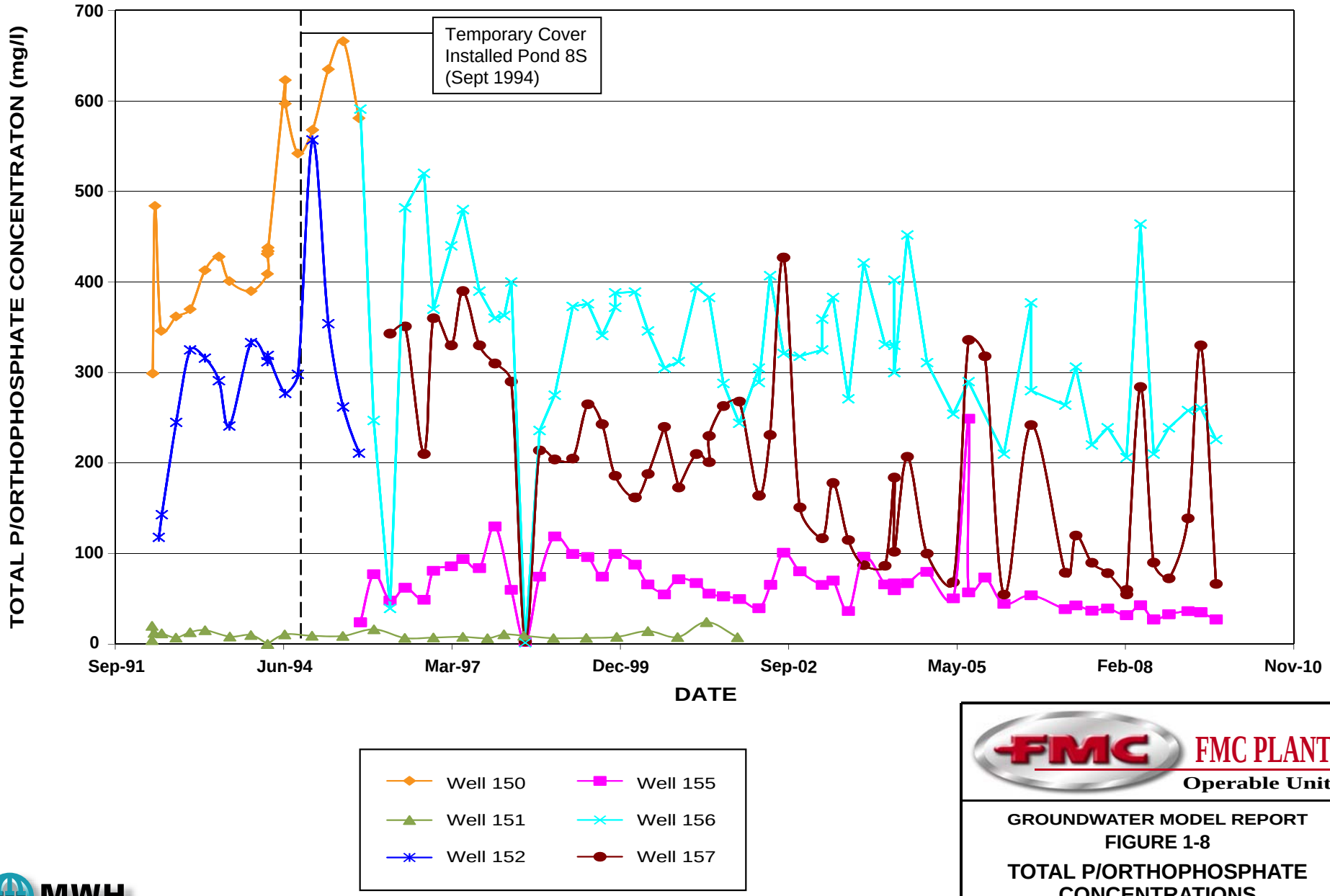
GROUNDWATER MODEL REPORT

FIGURE 1-7

ARSENIC CONCENTRATIONS
POND 8S DOWNGRADIENT WELLS

MWH

FILE *Fig 1-08_Total P_Orthophosphate Concentrations_Pond 8S Downgradient Wells.ai 12/17/09*



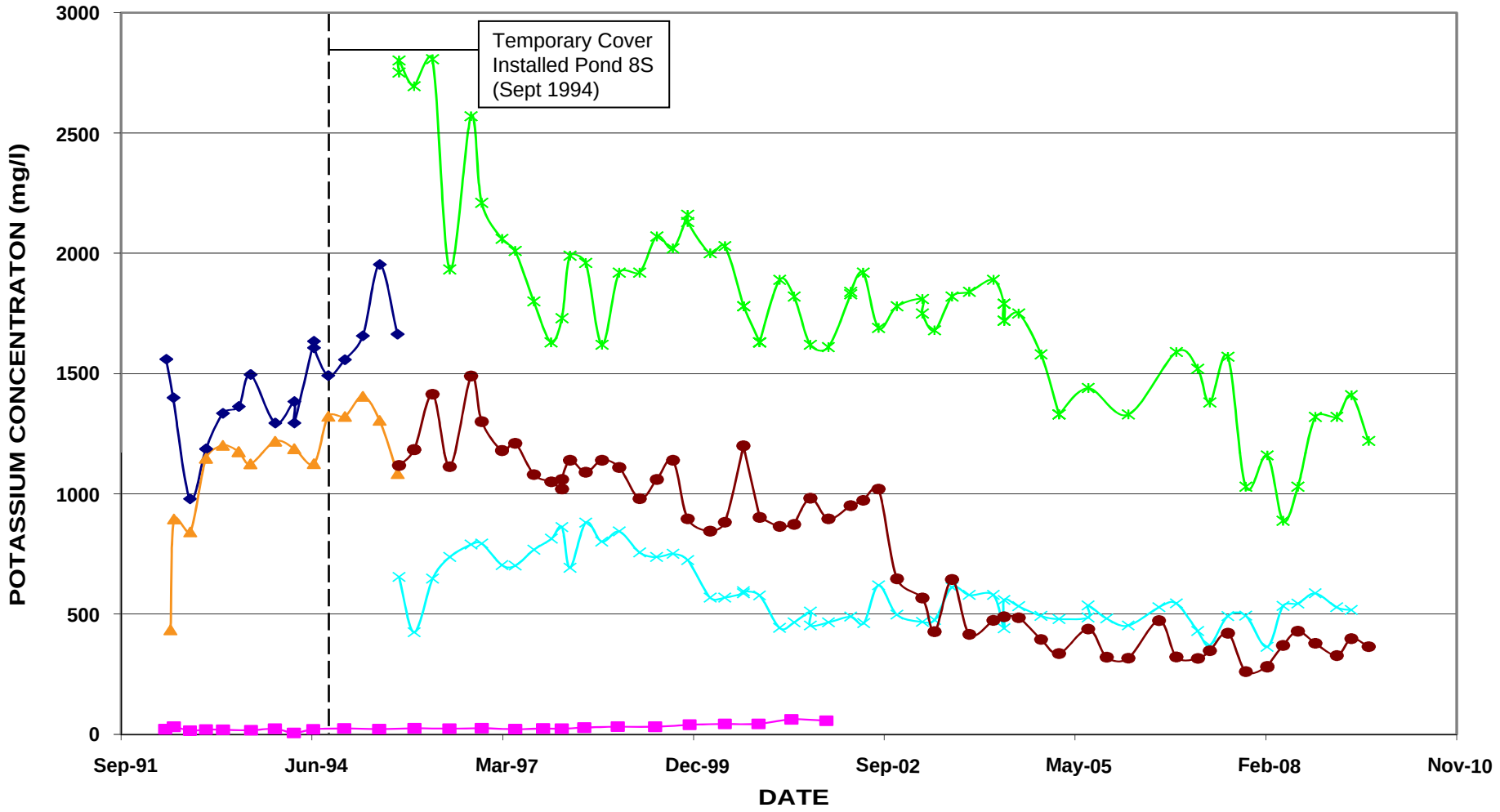
FMC PLANT
Operable Unit

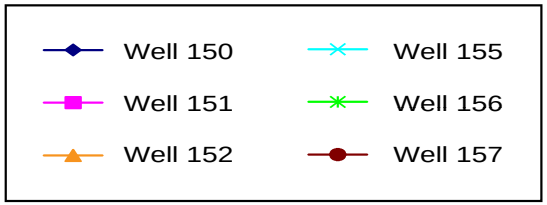
GROUNDWATER MODEL REPORT
FIGURE 1-8

TOTAL P/ORTHOPHOSPHATE CONCENTRATIONS
POND 8S DOWNGRADIENT WELLS

MWH

FILE *Fig 1-09_Potassium Concentrations_Pond 8S Downgradient Wells.ai 12/17/09*





FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 1-9

POTASSIUM CONCENTRATIONS
POND 8S DOWNGRADIENT WELLS

MWH

2.0 METHODOLOGY

The general modeling approach included construction of the models using site-specific physical and chemical data and data from the literature where site-specific data were unavailable, calibration of the models to match historical data, followed by performance of predictive simulations to evaluate future conditions under various remedial alternatives. The modeling effort included the use of the groundwater flow model MODFLOW, coupled with the advective transport model MODPATH to delineate extraction well capture zones and groundwater flowpaths, and the contaminant transport model MT3DMS to simulate contaminant distributions through time.

Calibration of the groundwater flow model was performed to match average water levels measured during 2008, which were assumed to represent quasi-steady-state conditions. The contaminant transport model was calibrated to match the contaminant concentrations from 2008 (averaged 2006-2008) monitoring data, as defined by the arsenic, total phosphate/orthophosphate, and potassium concentrations in groundwater presented in the *Groundwater Current Conditions Report for the FMC Plant Operable Unit* (MWH, 2009b). The initial contaminant distributions for the transport plume matching simulations were based on 1994 (averaged 1993-1994) monitoring data presented in the *Remedial Investigation Report for the Eastern Michaud Flats Site* (Bechtel, 1996). The primary goal of the contaminant transport calibration, or plume matching simulations, was to estimate contaminant retardation factors by reproducing 2008 general concentration distributions. For the contaminant transport model, the term “plume matching” is preferred to “calibration” due to the rather qualitative nature of this process compared to flow model calibration.

Following the contaminant transport plume matching simulations, predictive simulations were performed to compare the proposed SFS alternatives and to predict order-of-magnitude cleanup times. In these predictive simulations, the groundwater flow model was run assuming current hydraulic conditions (Simplot gypsum stack and extraction wells operating at present levels) until 2015, after which the Simplot gypsum stack was

assumed to be lined resulting in zero aquifer recharge beneath the gypsum stack while pumping extraction wells was assumed to continue (per direction from EPA as presented in minutes for the July 1, 2009 meeting, sent by B. Zavala in an e-mail communication dated 8 July 2009, provided in Appendix A). Transport parameters estimated during calibration were input to the model for predictive simulations. The predictive transport model was run starting with the observed 2008 plumes as the initial condition.

This model was developed based on information presented in the *Remedial Investigation Report for the Eastern Michaud Flats Site* (Bechtel, 1996), including the previous groundwater modeling effort presented in Appendix K of the RI, the *Pond 8S Solute Transport Study* (Bechtel, 1993), and the *Groundwater Current Conditions Report for the FMC Plant Operable Unit* (MWH, 2009b).

Modeling was performed in accordance with the Standard Guide for Subsurface Flow and Transport Modeling (ASTM, 2006) and the Region 10 Environmental Services Division Guidelines for Hydrogeologic Modeling (EPA, 1994), as well as standard methodology as described in Anderson and Woessner (1992) and Zheng and Bennett (1995).

This section describes the methodology used to construct and calibrate the groundwater flow and contaminant transport models, as well as the methodology used for the predictive simulations.

2.1 MODEL SOFTWARE

The codes MODFLOW, MODPATH, and MT3DMS were used in this modeling effort along with the Department of Defense Groundwater Modeling System (GMS) pre- and post-processor. MODFLOW is a modular three-dimensional finite-difference flow model developed by the U.S. Geological Survey (McDonald and Harbaugh, 1988; Harbaugh et al., 2000) to calculate the hydraulic head distribution and determine groundwater flow within a simulated aquifer. MODPATH is a particle tracking program developed by the U.S. Geological Survey (Pollock, 1989) to simulate groundwater flowpaths, and

advective transport of nonreactive contaminants (e.g., arsenic), and can be used to determine capture zones for production wells. MT3DMS is a modular three-dimensional solute transport model for simulation of advection, dispersion, and chemical reactions of contaminants in groundwater systems originally developed for the U.S. EPA (Zheng, 1998). MT3DMS is a multi-species transport model that can simulate advection, dispersion, retardation (sorption), and degradation of contaminants.

These models were selected because they can adequately represent and simulate the hydrogeologic conditions and contaminant transport processes that occur in the groundwater system underlying the FMC site. Furthermore, MODFLOW, MODPATH, and MT3DMS are well-documented, frequently used, and versatile programs that are widely accepted by the scientific and regulatory communities. These models are compatible with the GMS graphical user interface.

2.2 MODEL CONFIGURATION

Domain. The model domain, shown in Figure 2-1, includes the FMC plant site, much of the Simplot plant site, and the northern FMC properties. It extends from the western undeveloped area of the FMC plant site east to the Portneuf River (approximately 15,500 feet), and from the base of the Bannock Range in the south to approximately 4,000 feet north of I-86 (approximately 9,000 feet). The domain covers approximately 2,860 acres. The model domain boundaries were set to encompass the majority of the extensive geologic, hydrogeologic and groundwater quality data for the EMF Site and to minimize boundaries effects within the area of the FMC Plant Site and extending to the major sinks at the Portneuf River (e.g., Batiste Spring). Due to the relatively sparse hydrogeologic data (e.g., wells) in the far southern portions of the FMC and Simplot plant sites, those areas were not included within the domain. The predictive simulation results are all based on the same initial constituent concentrations measured in wells within the model domain, including wells downgradient from the identified (e.g., southern Simplot gypsum stack and FMC calciner solids storage area) and potential source areas that are located outside the southern model domain boundary. Thus the predictive simulation results are

all on a comparable basis with respect to those areas outside the southern domain boundary.

Grid. The finite difference grid consists of regularly spaced 50-foot square cells to minimize numerical errors associated with overly large grid cells while maintaining a reasonable balance with computation time and memory requirements. The model grid has 50,463 active cells per layer.

Layering. Four layers were used in the FMC groundwater flow model to represent the hydrogeologic system present at the site. Throughout much of the domain, these layers correspond to the dominant hydrogeologic units present at the site (the upper silt, shallow aquifer zone, lower silt, and the deep aquifer zone described in Section 1.2.1). However, in areas such as the Bannock Range (bedrock) to the south and the area near the Portneuf River (more continuous sands and gravels), these hydrogeologic units are not present, and the vertical discretization in these areas does not correspond to specific hydrogeologic units. Figure 2-2 presents a graphical representation of the model layering scheme.

Layer thicknesses vary throughout the domain and were based on interpolated data from 130 boreholes (see Appendix A; table containing data was provided to the EPA in an e-mail dated July 7, 2009). Layer 1 (the top layer) ranges from 10 to 300 feet thick, layer 2 from 1 to 95 feet thick, layer 3 from less than 1 to 124 feet thick, and layer 4 ranges from 1 to 183 feet thick.

2.3 GROUNDWATER FLOW MODEL

2.3.1 Boundary Conditions

Boundary conditions define hydraulic constraints at the boundaries of the model domain. There are three general types of boundary conditions:

- Specified head or Dirichlet (constant head)

- Specified flux or Neumann (constant flow, areal recharge, extraction wells)
- Head-dependent flux or Cauchy (drains, ditches, evapotranspiration).

No-flow boundaries are a special case of the specified flux boundary in which the flow is set equal to zero.

Specified Head Boundaries. The domain is surrounded by constant head (specified head) boundaries on all sides, except where the boundary coincides with the Simplot gypsum stack. To the east, the model domain boundary is coincident with natural hydraulic boundaries (the Portneuf River). Synthetic hydraulic boundaries were used along the northern, southern, and western edges of the model to create a smaller domain for convenience. Natural boundary conditions were not used here because the domain would have to be unnecessarily large. The small variation in water levels with time (on average, less than 2 feet over a year (MWH, 2009b) allowed the use of a steady-state flow model. Specified head values are based on a potentiometric surface map generated for the site (extrapolated to the boundaries) using average water level data from 2008 (collected in February, May, August, and November) and are assumed to represent quasi-steady-state conditions. Water levels were measured between 1990-2008 (see Appendix A of the GWCCR). During this period, water levels varied by 4 to 8 feet with highest levels in the mid- to late-1990s during a relatively wet period, and minimum values occurred in 2001-2002 during a period of below average precipitation in the region. There is no long-term trend in the water levels.

Portneuf River. The Portneuf River forms the downgradient eastern boundary of the model domain, and was simulated with specified head cells. The river forms a groundwater divide in the site area and was therefore a convenient choice for a model boundary. The specified head boundary condition can adequately simulate the river for the purposes of this study. Stretches of the river can gain or lose water based on water levels in the aquifer. The specified head elevations (representing the stage in the river) were interpolated between existing United States Geologic Survey gauging stations

13075500 Portneuf River at Pocatello, ID (Latitude 42°52'18", Longitude 112°28'05", Datum of gage is 4,418.41 feet above NGVD of 1929) and 13075910 Portneuf River at Tyhee, ID (Latitude 42°56'41", Longitude 112°32'40", Elevation of gage is 4,370 feet above NGVD of 1929).

Springs. Batiste Spring and Swanson Road Spring (aka the Spring at Batiste Road) were simulated using the MODFLOW drain package. An elevation (based on survey data of the ground surface elevation, 4382.6 and 4384.5 ft amsl for Batiste Spring and Swanson Road Spring, respectively) and conductance term (set high to approximate free discharge) were specified at the location of each spring. These values were adjusted within reasonable ranges during calibration to match estimated flows and water levels.

Areal Recharge. A net areal recharge value of 1.2 in/yr was assigned to the unirrigated and uncapped areas of the model domain. This represents approximately 10 percent of annual precipitation (12 inches) (Wood and Low, 1986). Evapotranspiration was not explicitly included in the model, rather it is assumed to be included in the net areal recharge value. Irrigated land located north of the site (north of I-86) was assigned a net areal recharge rate of 12 in/yr, ten times that of unirrigated land. Areas covered with low permeability geosynthetic cover systems ("RCRA-engineered caps") on the FMC plant site (see Figure 1-2), including Ponds 15S, 16S, the Phase IV ponds, and Pond 8S, and the calciner ponds) on the FMC site were assigned an areal recharge rate equal to 2×10^{-5} in/yr, based on previous modeling with the code HELP (Bechtel, 1998). The Simplot gypsum stack was assigned a recharge rate of 66 in/yr, corresponding to a net recharge value of approximately 700 gpm. Estimates of infiltration from the Simplot gypsum stack range from 800-900 gpm (Simplot, 2008). The lower value in the model is a result of the domain not encompassing the entire gypsum stack.

Extraction Wells. Currently, there is no significant extraction of groundwater at the FMC plant site. However, Simplot operates three water supply wells (SWP-4, SWP-5, and SWP-7), and 15 groundwater containment wells (401-415). Average extraction rates from 2008 were used in the model and are presented in Table 2-1. Average extraction

rates in 2008 for containment wells ranged from 0.2 gpm (at Well 408) to 290 gpm (at Well 412). Well 403 was not pumped in 2008. Extraction rates from the water supply wells (screened in the deep aquifer zone) ranged from 845 gpm (SWP-4) to 1365 gpm (SWP-7).

2.3.2 Model Parameters

Hydraulic Conductivity. Hydraulic conductivity varied by layer and was based on hydraulic test data when possible. Values are based on data collected during slug and pump tests presented in the EMF RI (Bechtel, 1996). Table 3.1-1 from the EMF RI that provides a tabulation of the slug and pump test calculated hydraulic conductivities and transmissivities was provided to EPA, IDEQ and the Tribes as a follow-up to the July 1, 2009 groundwater model meeting and is provided in Appendix B. Values used in the model were refined during the calibration to match observed water levels and estimated flux from the Bannock Range and to the Portneuf River and the springs. The hydraulic conductivity fields developed for each model layer are presented in Figures 2-3 through 2-6. Hydraulic conductivity values in layer 1 range from 0.3 to 1,000 feet/day, values in layer 2 range from 0.2 to 9,500 feet/day, values in layer 3 range from 0.2 to 500 feet/day, and values in layer 4 range from 0.6 to 3,500 feet/day. Extremely low conductivities are representative of the Bannock Range bedrock, while high conductivities are generally found northeast of the site towards the Portneuf River, where gravel and boulder deposits have been identified. Table 2-2 provides a comparison of the hydraulic conductivities calculated based on the slug and pump tests (EMF RI Table 3.3-1, provided in Appendix B) to the hydraulic conductivity for the cell and layers (layer 1 and 2 for shallow wells and layers 3 and 4 for deep wells) in the calibrated flow model associated with the Table 3.3-1 wells located within the model domain.

2.3.3 Calibration

During groundwater flow model calibration, model parameters were adjusted in sequential model simulations to produce estimated heads that iteratively better matched

field-measured values. After each calibration simulation, the model results were compared to the known data targets, which in this case were potentiometric head data from wells screened in the shallow aquifer. The initial parameter values were adjusted through calibration until the model produced results that adequately simulated the known data. As with any groundwater system, calibration using different combinations of parameter values can lead to the same outcome for a given steady-state scenario. However, if adequate data are available to characterize the hydrogeology and constrain the model parameters to a certain range of realistic, site-specific values, a more unique solution will result.

The calibration was evaluated through both qualitative and quantitative methods. Qualitatively, the simulated water table contour map and the actual water table contour map were compared visually to evaluate whether the patterns were similar. Quantitatively, the model results were analyzed statistically using the differences between actual target potentiometric head (water level) values and simulated potentiometric head values (this difference is known as the residual head), and comparing simulated and estimated flows from the Bannock Range and to the springs and river. Potentiometric head measurements from 140 monitoring locations were used for the calibration targets. The calibration statistics included (Anderson and Woessner, 1992):

- The mean error (the mean difference between measured and simulated heads)
- The absolute mean error (the mean of the absolute value of the differences between measured and simulated heads)
- The root mean squared error (the mean of the squared differences between measured and simulated heads).

The mean error provides information on the average error for all targets. This should be near zero; otherwise the predicted water levels are biased. However, a mean error of zero alone does not indicate that the calibration is acceptable, it simply indicates that the water levels are not biased high or low. The absolute mean error gives an indication of the total

error of the model and should be minimized. The mean squared error is similar to the absolute error, except that it gives more weight to points with greater error. Again, this error should be minimized. Another measure of the calibration is the normalized root mean squared error, which is based on the root mean squared error divided by the total head drop (maximum difference in water levels) across the model domain. For an acceptable calibration, this should be less than 10 percent, as a general rule-of-thumb (Rumbaugh and Rumbaugh, 2001). Residuals also were examined spatially to assist in adjusting parameters to achieve better correspondence between modeled and actual water level values in subsequent calibration simulations. The calibration statistics for the model are provided in Section 3.0.

Calibration Targets. Potentiometric head values predicted with steady-state simulations were calibrated against 2008 average water levels from 140 monitoring locations throughout the model domain. 112 monitoring wells were screened in the shallow aquifer zone, while 28 were screened in the deep aquifer zone. The potentiometric head values used for calibration targets were the average of water level measurements collected in February, May, August, and November 2008. Water levels varied by 1.7 feet on average (but up to 2.5 feet) over the course of the year in these wells. Table 2-3 presents the monitoring wells and observed (2008 average) water levels used for calibration targets and the flow model simulated water level and residual. In addition, water levels were relatively constant over the long term, exhibiting no long-term trend and little change. Throughout the period of 1990 to 2008, water levels in monitoring wells fluctuated seasonally by approximately 2 to 4 feet. No significant changes in flow directions that would necessitate a transient flow model have been observed. Hydrographs for these wells are included in Appendix A of the GWCCR. These target water levels represent quasi-steady-state conditions.

Flows from the Bannock Range and to the springs and river were estimated in the groundwater flow modeling report presented in the EMF RI (Bechtel, 1996). These estimates were compared to model simulated flows to further evaluate the flow model calibration.

2.4 CONTAMINANT TRANSPORT MODEL

2.4.1 Contaminants Simulated

The inorganic groundwater constituents included in the contaminant transport model were arsenic, total phosphate/orthophosphate, and potassium. Arsenic was simulated because it is the primary groundwater contaminant exceeding state and federal water quality standards (maximum contaminant level [MCL] is 0.010 mg/l for arsenic). Total phosphate/orthophosphate was simulated because it is the primary surface water contaminant from groundwater. Potassium was simulated because it is a key indicator of FMC source areas (Simplot sources are low in potassium relative to FMC sources).

2.4.2 Transport Parameters

Input Parameters to the Transport Model. Dispersivity, porosity, sorption (or retardation) and degradation are all required as input parameters in the transport model and were estimated from field and/or laboratory data (when possible) and literature values. Due to the uncertainty associated with estimating these parameters, the values were adjusted through calibration (plume matching). The parameter values that resulted in the best plume match were then used in the predictive simulations. Because phosphorus, arsenic, and potassium do not decay, a degradation rate of zero was assumed. Final calibrated transport model parameter values are summarized in Table 2-4.

Dispersivity. Initial estimates of dispersivity for the plume were based on the typical range of values expected for the plume lengths observed. Longitudinal dispersivity is frequently reported as 10 percent of the plume length. Assuming the arsenic plume was approximately 12,000 feet long in 2008, the longitudinal dispersivity would be 1,200 feet. Gelhar et al. (1992) examined many plumes and related longitudinal dispersivity (α_L) to plume length (L). Xu and Eckstein (1995) fitted a curve to the

longitudinal dispersivity data presented by Gelhar et al (1992), which was later corrected by Al-Suwaiyan (1996) and is:

$$\alpha_L = 0.82\ (\log_{10}L)^{2.446}$$

This equation assumes that the measurements are in meters. This equation yields a longitudinal dispersivity of approximately 60 feet for the contaminant plumes. Transverse dispersivity is typically 10 percent of longitudinal dispersivity. Vertical dispersivity is typically 1 percent of longitudinal dispersivity.

These calculated values were used as initial dispersivity estimates in the model and were adjusted through the plume matching process. Dispersivity values were varied until the plume widths and lengths were reproduced. Based on the final calibration, the longitudinal dispersivity was estimated to be 125 feet. Transverse dispersivity was assumed to be 10 percent of longitudinal dispersivity, and vertical dispersivity was assumed to be 1 percent of longitudinal dispersivity.

Porosity and Bulk Density. For contaminant mass calculations, total porosity should be used to accurately calculate the mass in the aqueous and solid phases. For advective velocity calculations, effective porosity should be used. However, because MT3DMS allows only one porosity value to be entered for any given location, and plume migration is the primary objective of the modeling, effective porosity was used in the model. The effective porosity was estimated to be 35 percent based on previous studies (Bechtel, 1993). Assuming a uniform effective porosity across the site is reasonable because the contaminated portion of the site consists solely of unconsolidated deposits and the relative uncertainty associated with estimating porosity (plus or minus 15 percent) is small compared with that of hydraulic conductivity (orders of magnitude). The bulk density used in the model was 1.5 grams per cubic centimeter (g/cm^3), typical of sandy soils (Troeh and Thompson, 2005), which corresponds to a total porosity of 43 percent, assuming a particle density of 2.65 g/cm^3.

Sorption and Retardation. Partitioning of contamination between the aqueous and solid phases, termed sorption, leads to retardation of the contaminant plume relative to the advective velocity of the groundwater. Depending on the soil composition and the contaminants present, sorption can significantly retard the migration of a contaminant plume with respect to groundwater flow. Sorption can also limit the effectiveness of remedial actions involving pumping, by increasing the number of pore volumes or flushes required to remove the contaminant from the aquifer, thus reducing mass removal rates. The retardation factor, R, describes the retardation of a contaminant with respect to the average linear velocity of groundwater:

R = average linear velocity of groundwater/velocity of contaminant

Sorption depends on the properties of the contaminants (e.g., electrical charge, polarity, mass, size, etc.) and the properties of the aquifer (e.g., cation exchange capacity, hydrous ferric iron oxide surfaces, organic carbon content, etc.). Sorption of contaminants onto aquifer material typically can be described by linear, Langmuir, or Freundlich models. Depending on the concentrations present and the number of sorption sites, behavior can be similar to the linear model for both Langmuir and Freundlich isotherms. In the linear model, there is a direct linear relationship between the aqueous contaminant concentration and the sorbed concentration:

$$S=K_dC$$

where: S = mass of sorbed contaminant per dry mass of aquifer material (mg/kg),

K_d = distribution coefficient (l/kg), and

C = aqueous contaminant concentration (mg/l).

For the Langmuir and Freundlich isotherms, sorption sites become limited at higher concentrations, thus the behavior becomes non-linear. For a specific contaminant that

exhibits linear sorption, a retardation factor can be calculated with the distribution coefficient (Zheng and Bennett, 1995):

$$R = 1 + \rho_b K_d / n$$

where: ρ_b = dry soil bulk density (kg/l), and

n = aquifer porosity

Initial retardation rates used in the model were based on these calculated values, and were varied during calibration.

Sorption of arsenic is highly dependent on the pH and oxidation reduction potential (ORP) conditions of groundwater as well as hydrous ferric oxide (HFO) coatings on the aquifer matrix (Hem, 1985). Given the pH (relatively neutral, not including the Phosphoric Acid Plant at Simplot) and redox conditions in groundwater at the FMC site, arsenic likely occurs as the arsenate species (As^{5+}) $H_2AsO_4^-$ or $HAsO_4^{2-}$, or the arsenite species (As^{3+}) H_3AsO_3 or $H_2AsO_3^-$. Arsenate species are generally stable under oxidizing conditions while arsenite species are generally stable under reducing conditions. Under oxidizing conditions, arsenic sorbs to HFO, which often occurs as coatings on the aquifer matrix. Under mildly reducing conditions, arsenic generally will be in the form of arsenite (As^{3+}), which results in the least sorption. Under highly reducing conditions, if dissolved iron and sulfide are present, arsenic can coprecipitate with iron sulfide. Sorption of arsenic will generally be reduced in the presence of high concentrations of orthophosphate, as the orthophosphate will out-compete the arsenate for sorption sites.

A wide range of arsenic sorption values has been reported in the literature. This is expected given the variations in sorption caused be differences in pH, ORP, aquifer matrix (ferric hydroxide coatings), aqueous sulfide concentrations (which would act to precipitate arsenic, thus reducing aqueous concentrations and effectively increasing

sorption), and aqueous orthophosphate concentrations (which can compete for sorption sites, thus reducing arsenic sorption). Arsenic sorption values reported include:

- 5.86 to 19.4 L/kg (Battelle Memorial Institute, 1989),
- 1 to 10 L/kg (Looney et al., 1987),
- 1.0 to 8.3 L/kg for As^{3+} (Baes and Sharp, 1983; Baes et al., 1984),
- 29 L/kg for for As^{3+} at a pH of 6.8 (U.S. EPA, 1996)
- 1.9 to 18 L/kg for As^{5+} (Baes and Sharp, 1983; Baes et al., 1984),

In the Pond 8S Solute Transport Study (Bechtel, 1993), sorption values for arsenic were estimated with measured concentrations in water and soil from the fine-grained and coarse-grained aquifer materials. This yielded median sorption values for arsenic of 300 L/kg for the saturated fine-grained aquifer material (silt and silty clay) and 60 L/kg for the saturated coarse-grained aquifer material. Final sorption values used in the Bechtel calibrated Pond 8S solute transport models for arsenic for the fine-grained saturated zone were 0.4 L/kg in the vertical model and 0.45 L/kg in the horizontal model (Bechtel, 1993).

Like arsenic, sorption of orthophosphate is pH dependent. Given the groundwater conditions at the FMC Plant site, which are relatively neutral (not including pH influences from the Simplot gypsum stack in the joint fenceline area or downgradient from the Simplot Phosphoric Acid Plant), orthophosphate likely occurs as either $H_2PO_4^-$ (dominant below pH 7) or HPO_4^{2-} (dominant above pH 7) (Hem, 1985). Because orthophosphate generally occurs as an oxyanion, its sorption is expected to be similar to arsenic.

Sorption values for orthophosphate reported in the literature are limited. Rao and Davidson (1982) reported Langmuir isotherm values for orthophosphate in a variety of clay soils. Linear adsorption isotherms were assumed with the Langmuir parameters, resulting in K_d values ranging from 5 to 105,000 L/kg. Based on data presented in Parkhurst, Stollenwerk, and Colman (2003), sorption values for orthophosphate were

calculated to be 0.1 L/kg for a concentration of 0.03 mg/l and 0.006 L/kg for a concentration of 6 mg/l. Based on data presented in Fetter (1977), sorption values for orthophosphate were calculated to be 0.02 L/kg for phosphate concentrations of less than 4 mg/l and 0.007 L/kg for concentrations greater than 4 mg/l.

In the Pond 8S Solute Transport Study Study (Bechtel, 1993), sorption values for orthophosphate were estimated with measured concentrations in water and soil from the fine-grained and coarse-grained aquifer materials. This yielded median sorption values for orthophosphate of 2 L/kg for the saturated fine-grained aquifer material (silt and silty clay) and 1 L/kg for the saturated coarse-grained aquifer material. Final sorption values used in the Bechtel calibrated solute transport models for orthophosphate for the fine-grained saturated zone were 1.0 L/kg in the vertical model and 0.2 L/kg in the horizontal model (Bechtel, 1993).

Potassium occurs as a monovalent cation that sorbs to negatively charged clays. Information regarding sorption of potassium is limited. Sheppard and Thibault (1990) reported a sorption value of 15 L/kg for potassium-40 (a naturally-occurring isotope of potassium). The Washington Savannah River Company (2007) reported a potassium sorption value of 75 L/kg.

Sorption coefficients used in the final calibrated model for arsenic, total phosphate/orthophosphate, and potassium were 2.8 ml/g, 2.3 ml/g, and 2.8 ml/g, respectively. These sorption coefficients result in retardation factors of 13, 11, and 13 for arsenic, total phosphate/orthophosphate, and potassium, respectively.

MT3DMS is not capable of modeling geochemical conditions and individual arsenic and phosphorous species present, rather total arsenic and total phosphorus were simulated. This is a necessary simplification and given that regulatory levels for arsenic and phosphorus are based on total values, this simplification does not significantly reduce the usefulness of the model results.

2.4.3 Initial Conditions

Initial Conditions for Plume Matching Simulations. The average 1993-1994 contaminant distributions for arsenic, total phosphate/orthophosphate, and potassium (Bechtel, 1996) were input to the transport model through interpolation. Concentrations in wells screened in the shallow aquifer zone were applied to model layers 1 and 2, while concentrations in wells screened in the deep aquifer zone were applied to model layers 3 and 4. The simulation was then run through 2008 and simulated contaminant distributions were compared to observed distributions. The purpose of this calibration was to better estimate transport parameters used in the predictive simulations by matching the plume length, width, and general contaminant distribution. Dispersivity, retardation, and degradation rates were adjusted until an adequate reproduction of the 2008 plumes (constructed with data collected in 2006-2008) was achieved.

Initial Conditions for Predictive Simulations. Average 2006 through 2008 contaminant distributions for arsenic, total phosphate/orthophosphate, and potassium (MWH, 2009b) were used to assign the contaminant distributions for predictive simulations. The model was then run forward for 100 years to predict contaminant fate and transport. No continuing FMC plant site sources were assumed for these simulations, because all historical source areas have been controlled (closed and/or capped) or are expected to be subject to source controls consistent with the soil remedial alternatives under evaluation in the SFS.

2.4.4 Time

The underlying flow fields used to calculate advective transport velocities were run under steady-state conditions (the first representing 2008 to 2015 conditions with the Simplot gypsum stack in operation, the other representing 2015 to 2108 assuming conditions with zero recharge from the lined gypsum stack) while the transport model was run under transient conditions to predict contaminant migration. The transport model was run for

100 years for the predictive simulations, representing 100 years into the future from present 2008 conditions.

Time Discretization. To avoid numerical errors and solution stability problems, the maximum time step lengths for transient transport simulations are calculated automatically by MT3DMS. This critical time step length is based on the minimum grid spacing within the model, average advective velocities, retardation factors, and dispersion (Zheng and Bennett, 1995). The Courant number (C_r) is defined as:

$$C_r = v_x \, \Delta t/\Delta x$$

Where v_x is the advective velocity in the x direction, Δt is the time step length, and Δx is the node spacing in the x-direction. Ideally, the Courant number should be approximately 1 and should not exceed 2. For a three-dimensional model with solute retardation this yields a transport time step length of:

$$\Delta t = R*\min(\Delta x/v_x, \Delta y/v_y, \Delta z/v_z)$$

Where Δt is the time step length; Δx, Δy, and Δz is the node spacing in the x, y, and z directions; and v_x, v_y, and v_z is the advective velocity in the x, y, and z directions. If dispersion controls the length of the time step, then the maximum transport time step length for a three-dimensional simulation is:

$$\Delta t = 0.5R \,/\, \{[D_{xx}/(\Delta x)^2 + D_{yy}/(\Delta y)^2 + D_{zz}/(\Delta z)^2)$$

Where D_{xx}, D_{yy}, and D_{zz} are the principal components of the dispersion coefficient.

The MT3DMS transport simulation time step length calculated for each alternative is about 4.6 hours.

2.4.5 Plume Matching

The plume matching process involved adjusting values for model parameters in sequential model simulations to produce contaminant plume maps. Contour maps of the actual plumes were visually compared to concentration distributions produced by the model. Simulated concentrations at monitoring wells were also compared to actual concentrations. The initial transport parameter values were adjusted through the plume matching process until the model results adequately simulated the known data. Only general changes made through plume matching are described below; specific details are not presented.

The transport model was "calibrated" by varying dispersivity, effective porosity, source strength, and retardation factors. As previously stated, the plume matching simulations started in 1994 and ended in 2008. Results of the plume matching are discussed in Section 3.2.

Several simplifying assumptions were made concerning the adjacent Simplot site. These assumptions were necessary for modeling purposes, and to facilitate a timely completion of the FMC SFS. Concentrations along the joint fence line and northern Simplot boundary were held constant at 1994 levels using constant concentration source cells. Gypsum stack infiltration was also held constant, as in the calibrated flow model. Extraction wells were not operated, as they came online late in the calibration period. Due to the constant concentration cells outside the extraction zone, they would have no effect on results.

Ongoing sources at areas of high concentration within the FMC plant site were simulated. Pond 8S was assigned a recharge concentration of 0.62 mg/l for arsenic, 3,700 mg/l for total phosphorus/orthophosphate, and 3,000 mg/l for potassium. The Pond 3E - 6E area (now beneath Pond 15S and the Phase IV ponds) was assigned a recharge rate of 0.62 mg/l for arsenic. As described in the GWCCR, these historic ponds do not appear to be a continuing source of total phosphorus/orthophosphate or potassium to groundwater.

Input concentrations were based on analysis presented in the *Pond 8S Solute Transport Study* (Bechtel, 1993).

2.5 PREDICTIVE SIMULATIONS

Following the transport calibration, the model was used for predictive simulations to compare the fate of contaminants under the proposed groundwater remedial alternatives. The 2008 plumes were input to the model as the initial condition for the transport predictions, and simulations were conducted for 100 years into the future for each remedial alternative. No ongoing FMC plant site sources were simulated in the predictive simulations. The source areas were assumed to be isolated from the groundwater system, because all historical source areas have been controlled (closed and/or capped) or are expected to be subject to source controls consistent with the soil remedial alternatives under evaluation in the SFS.

2.5.1 Groundwater Alternatives Simulated

The four proposed groundwater remedial alternatives presented and described in detail in the SFS report include:

- **Alternative 0** No action (as described in Section 1, a simulation was not run for this alternative) ;
- **Alternative 1** Source controls, institutional controls and long-term monitoring (LTM);
- **Alternative 2** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, and A) discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation / evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

- **Alternative 3** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, groundwater extraction at specific source areas, and A) on-site treatment and discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation/evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

Three predictive simulations were performed to evaluate and compare the effectiveness of Alternatives 1, 2 and 3. The simulations for these 3 alternatives assumed Soil Alternative 2 was selected for modeling purposes. The FMC Plant Site remedial areas identified for capping (and infiltration reduction) under Alternative 2 are essentially the same as Soil Alternatives 3 through 6; therefore, additional simulations based on the other soil alternatives was not performed. Areal recharge to the flow model was modified for predictive simulations to simulate the FMC assembled soil remedial Alternative 2 cap areas as shown on Figure 2-7. Recharge rates in the predictive runs are the same as those used in the calibration, except for the areas of proposed ET caps which assumed a recharge rate of 0.05 in/yr (see Figure 2-7). Recharge beneath the ET caps was based on UNSAT-H predictions (Bechtel, 1998). Recharge beneath gamma caps was conservatively assumed to remain the same as natural recharge (10% of precipitation).

For Alternatives 2B and 3B, additional recharge was added to the proposed infiltration area upgradient of the plumes at the west end of the FMC Plant Site to simulate infiltration of treated extraction system water. Because the proposed infiltration area was partially outside the model domain, a smaller area was used in the model (approximately 49 acres), and hence a higher recharge value (0.48 in/day for Alternative 2B and 0.64 in/day for Alternative 3B) was assigned to match the volumes of water presented in Appendix C (0.3 in/day over 83 acres for Alternative 2B, and 0.3 in/day over 104 acres for Alternative 3B). This additional recharge did not make a substantive difference in flow directions or velocities, and impacts to predictive transport simulations were

minimal when compared to Alternatives 2A and 3A. Therefore, only results from Alternatives 2B and 3B are presented in Section 3.

Assumptions concerning the Simplot site were similar to those made during the plume matching process. Concentrations along the joint fence line and the northern Simplot boundary were again held constant, but at average 2006-2008 levels. Extraction system wells and production wells were run at current average operating levels. Two steady state groundwater models were used, the first representing continued gypsum stack operation from present to 2015, the second representing 2015 into the future with gypsum stack infiltration set to zero (lined).

Results of the predictive simulations are described in Section 3.0.

TABLE 2-1
EXTRACTION RATES FROM EXISTING SIMPLOT WELLS

Well ID	Easting	Northing	Aquifer Zone	Extraction Rate (2008 Avg)
401	558176.9	451159.2	Deep	-22
402	558132.7	451419.2	Deep	-15
403	560438.4	451863.7	Shallow	0
404	560604.3	451883.4	Shallow	-1
405	560736.4	451998.7	Shallow	-2
406	560878.1	452144.6	Shallow	-10
407	561010.3	452245.9	Shallow	-4
408	561120.7	452318.6	Shallow	-0.2
409	561244.3	452375.9	Shallow	-3
410	560696.3	452413.3	Deep	-88
411	561072.9	452387.9	Deep	-56
412	560471.4	452458.5	Shallow/Deep	-290
413	561324.4	452645.3	Shallow/Deep	-91
414	560062.7	453154.0	Shallow	-22
415	558594.1	452253.0	Shallow/Deep	-43
SWP-4	560090.0	452765.0	Deep	-845
SWP-5	560062.0	453069.0	Deep	-1,232
SWP-7	559644.0	453459.0	Deep	-1,365

Notes:
Coordinates are in state plane feet.
Extraction rates are in gallons per minute (gpm).
Extraction rates taken from the Simplot Groundwater Extraction System Reports, First through Fourth Quarter 2008.

TABLE 2-2 Comparison of EMF RI Table 3.3-1 Hydraulic Conductivity to Calibrated Flow Model Hydraulic Conductivity

EMF Remedial Investigation Table 3.3-1 [1]			Calibrated Flow Model Hydraulic Conductivity (ft/day)	
Area	**Shallow Wells**	**Hydraulic Conductivity (ft/day)**	**Layer 1**	**Layer 2**
MICHAUD FLATS	104	126	1.7	422
	108	286	0.3	648
	110	108	312	1253
	111	397	0.3	615
	113	397	1.6	137
	126	166	1.6	321
	134	309	0.3	714
	135	89.3	1.4	609
	139	53.9	1.8	335
	140	275	1.7	704
	146	173	148	309
	148	69.5	1.5	106
	150	1000	1.8	591
	153	935	1.7	145
	154	49.3	1.7	146
	501	257	0.3	607
	514	111	0.3	897
	515	29.8	0.3	797
	516	66.0	189	773
BANNOCK RANGE	106	12.2	0.6	392
	142	1.98	1.6	0.2
	300	0.69	0.3	0.2
	301	0.03	Outside Domain	
	304	1.41	0.3	0.2
	306	3.32	0.3	0.2
	307	281	0.3	1000
	308	71.2	0.3	1002
	313	51.0	158	0.2
	316	28.9	284	1892
	323	3.40	0.3	15
	325	15.5	313	831
	333	28.1	313	60
	PEI-2	2.83	0.3	0.2
	PEI-5	1.28	Outside Domain	
PORTNEUF RIVER	312	3970	313	450
	324	154	313	750
	327	334	1000	5678
	328	522	313	5644
	502	394	313	6232
	503	4760	1000	9500
	505	1038	1000	9500
	507	1810	300	6043
	517	2040	313	5165
	518	422	1000	9095

[1] Pump and slug test calculated hydraulic conductivity (K) and transmissivity values taken from the EMF Remedial Investigation Report Table 3.3-1, consult the original table for details.

TABLE 2-2 Comparison of EMF RI Table 3.3-1 Hydraulic Conductivity to Calibrated Flow Model Hydraulic Conductivity (Continued)

EMF Remedial Investigation Table 3.3-1 [1]			Calibrated Flow Model K (ft/day)	
Area	**Deep Wells**	**Hydraulic Conductivity ft/day**	**Layer 3**	**Layer 4**
MICHAUD FLATS	103	14.7	0.9	938
	107	62.4	0.9	3500
	109	14.6	0.9	3500
	125	205	1.3	938
	133	340	0.9	3500
	145	609	0.9	3500
	500	190	0.9	3500
BANNOCK RANGE	315	33.7	500	938
PORTNEUF RIVER	317	28.1	500	938
	319	28.4	500	3500
	321	425	500	938
	322	794.7	500	938
	329	1030	0.9	938
	330	160	0.9	3500
	504	201	500	3500
	506	652	500	938
	512	1640	Outside Domain	
	519	45.0	500	3500

EMF Remedial Investigation Table 3.3-1 [1]			Calibrated Flow Model K (ft/day)	
Area	**Production Wells**	**Transmissivity (ft2/day)**	**Layer 3**	**Layer 4**
MICHAUD FLATS	FMC-6	7370	0.9	3500
	32ACD1	35100	Outside Domain	
	32DDC1	135700	Outside Domain	
	33BAA1	21900	Outside Domain	
	33CCD1	41400	Outside Domain	
	34ADD1	40400	Outside Domain	
	34DCC1	36600	Outside Domain	
	35DDC1	164400	Outside Domain	
	3ACD1	41200	Outside Domain	
	3BDC1	444000	Outside Domain	
	4BBA1	38500	Outside Domain	
	5BDA1	36800	Outside Domain	
	8ADA1	27300	Outside Domain	
	9CAC1	199000	Outside Domain	
	12BBC1	54700	0.9	3500
PORTNEUF RIVER	SWP-7	227270	Outside Domain	

[1] Pump and slug test calculated hydraulic conductivity (K) and transmissivity values taken from the EMF Remedial Investigation Report Table 3.3-1, consult the original table for details.

TABLE 2-3
MONITORING WELLS USED FOR CALIBRATION TARGETS AND MODEL RESIDUALS
(page 1 of 4)

Well ID	Easting	Northing	Aquifer Zone	Observed Water Level	Simulated Water Level	Residual
101	551859.2	448838.9	Shallow	4396.1	4397.3	1.2
104	554270.2	450145.9	Shallow	4395.9	4395.1	-0.8
106	556230.9	451116.9	Shallow	4395.0	4393.4	-1.6
108	556573.7	452316.5	Shallow	4392.2	4391.4	-0.8
110	558378.9	453398.7	Shallow	4384.2	4385.5	1.3
111	556296.9	452890.2	Shallow	4392.1	4391.1	-1.0
112	554655.3	452105.6	Shallow	4394.6	4393.8	-0.8
113	552482.1	449982.1	Shallow	4395.8	4396.5	0.7
114	553029.9	449848.7	Shallow	4395.7	4396.0	0.3
115	552938.2	449999.6	Shallow	4395.6	4396.1	0.5
116	554560.0	449931.2	Shallow	4396.4	4395.1	-1.3
120	555064.5	450379.6	Shallow	4395.6	4394.6	-1.0
121	556105.7	451766.8	Shallow	4393.6	4392.5	-1.1
122	556282.4	452470.2	Shallow	4392.6	4391.5	-1.1
123	557000.1	452221.3	Shallow	4392.3	4391.2	-1.1
124	552028.7	450362.3	Shallow	4396.0	4396.6	0.6
127	552687.2	451067.8	Shallow	4395.6	4395.9	0.3
128	552683.9	450494.0	Shallow	4395.6	4396.1	0.5
131	553742.7	450212.0	Shallow	4395.5	4395.3	-0.2
134	555354.2	451636.8	Shallow	4394.2	4393.5	-0.7
135	555405.7	451154.5	Shallow	4394.8	4393.8	-1.0
136	557882.9	451860.7	Shallow	4392.1	4391.0	-1.1
137	552945.9	449345.5	Shallow	4396.1	4396.5	0.4
139	553167.0	450368.1	Shallow	4395.3	4395.8	0.5
140	554203.3	451119.7	Shallow	4394.9	4394.7	-0.2
141	555009.0	451106.5	Shallow	4394.9	4394.1	-0.8
143	557172.8	451639.0	Shallow	4392.9	4392.1	-0.8
145	557552.3	452188.7	Shallow	4391.6	4390.4	-1.1
146	557382.2	453214.1	Shallow	4389.3	4388.6	-0.7
147	550769.3	450622.8	Shallow	4396.3	4397.5	1.2
148	551187.8	450479.4	Shallow	4396.1	4397.2	1.1
149	551254.4	450047.3	Shallow	4396.1	4397.2	1.1
151	555023.3	450773.5	Shallow	4394.7	4394.4	-0.3
154	550197.8	449702.0	Shallow	4396.5	4397.8	1.3
155	554398.5	450432.7	Shallow	4395.6	4394.9	-0.7
156	554633.2	450418.6	Shallow	4395.7	4394.8	-0.9
157	554874.5	450429.5	Shallow	4395.4	4394.7	-0.7
158	554944.7	450027.9	Shallow	4396.5	4394.9	-1.6
159	554680.1	451036.0	Shallow	4395.0	4394.4	-0.6
164	558064.3	449964.9	Shallow	4432.8	4430.5	-2.3
165	551986.2	449237.3	Shallow	4396.0	4397.1	1.1

TABLE 2-3
MONITORING WELLS USED FOR CALIBRATION TARGETS AND MODEL RESIDUALS
(page 2 of 4)

Well ID	Easting	Northing	Aquifer Zone	Observed Water Level	Simulated Water Level	Residual
166	552802.0	450004.0	Shallow	4395.6	4396.2	0.6
167	554015.5	449404.1	Shallow	4397.1	4395.9	-1.2
168	553285.9	450082.2	Shallow	4395.5	4395.7	0.2
169	550035.8	448217.2	Shallow	4397.1	4398.7	1.6
171	551237.2	449596.5	Shallow	4396.2	4397.3	1.1
172	551080.8	449271.6	Shallow	4396.3	4397.6	1.3
174	549303.4	449232.7	Shallow	4397.1	4398.6	1.5
175	549119.0	449797.1	Shallow	4397.0	4398.5	1.5
176	550019.0	450291.6	Shallow	4396.6	4397.9	1.3
177	550166.4	450022.2	Shallow	4396.9	4397.8	0.9
178	550275.2	449473.9	Shallow	4396.9	4397.9	1.0
179	550185.4	449247.5	Shallow	4396.8	4398.0	1.2
180	550976.2	449088.4	Shallow	4396.4	4397.7	1.3
181	551188.5	449666.4	Shallow	4397.3	4397.3	0.0
182	551105.4	449359.7	Shallow	4397.2	4397.5	0.3
189	557824.0	451486.0	Shallow	4392.9	4393.2	0.3
190	557256.0	451000.4	Shallow	4394.0	4395.1	1.1
307	558139.1	450908.7	Shallow	4396.1	4396.8	0.7
308	558146.5	451429.3	Shallow	4393.0	4393.2	0.2
310	558585.5	452273.9	Shallow	4383.5	4387.7	4.2
312	558569.5	453120.0	Shallow	4384.5	4385.9	1.4
316	560642.9	452012.6	Shallow	4386.9	4384.3	-2.6
318	561410.5	452818.5	Shallow	4384.5	4383.9	-0.6
320	559829.5	453494.6	Shallow	4383.9	4383.7	-0.2
323	559078.5	451469.9	Shallow	4396.7	4394.0	-2.7
324	558564.0	452771.0	Shallow	4385.4	4386.8	1.4
325	559294.4	452735.0	Shallow	4384.3	4385.1	0.8
327	560793.9	453211.8	Shallow	4384.0	4383.5	-0.5
328	562236.8	452717.3	Shallow	4385.0	4384.6	-0.4
331	559113.8	453486.4	Shallow	4384.0	4384.8	0.8
332	561497.0	452470.0	Shallow	4385.2	4384.4	-0.8
334	560087.0	452772.0	Shallow	4384.3	4383.6	-0.7
336	558230.3	451151.1	Shallow	4393.6	4394.7	1.1
338	560709.8	452444.8	Shallow	4384.6	4383.9	-0.7
339	560721.5	452421.6	Shallow	4384.9	4383.9	-1.0
340	559784.1	453218.1	Shallow	4383.8	4383.7	-0.1
341	559587.3	452492.0	Shallow	4384.7	4384.5	-0.2
342	559430.1	452187.5	Shallow	4391.1	4385.6	-5.5
348	560177.2	453323.7	Shallow	4383.3	4383.4	0.1
350	561951.5	452546.0	Shallow	4385.0	4384.8	-0.2
351	559634.3	452154.1	Shallow	4388.7	4384.7	-4.0

TABLE 2-3
MONITORING WELLS USED FOR CALIBRATION TARGETS AND MODEL RESIDUALS
(page 3 of 4)

Well ID	Easting	Northing	Aquifer Zone	Observed Water Level	Simulated Water Level	Residual
352	559173.3	452042.3	Shallow	4391.5	4389.4	-2.1
353	559975.3	452443.5	Shallow	4384.8	4383.9	-0.9
354	560255.4	451981.9	Shallow	4385.7	4384.2	-1.5
355	560067.2	451643.4	Shallow	4391.4	4392.0	0.6
356	560947.5	452325.6	Shallow	4386.0	4384.2	-1.8
357	561029.8	452175.7	Shallow	4387.5	4384.5	-3.0
358	560952.6	451960.0	Shallow	4389.0	4384.8	-4.2
367	559654.2	453238.5	Shallow	4383.9	4383.9	0.0
501	554633.0	452767.7	Shallow	4393.0	4393.6	0.6
502	558079.5	454363.3	Shallow	4384.2	4385.5	1.3
503	560800.8	454363.7	Shallow	4383.5	4382.8	-0.7
505	561200.5	454047.2	Shallow	4383.8	4383.1	-0.7
506	563065.1	452702.9	Shallow	4385.4	4385.0	-0.4
507	563053.6	452708.1	Shallow	4385.3	4385.0	-0.3
514	553463.5	453442.7	Shallow	4394.7	4394.6	-0.1
515	555307.3	454045.1	Shallow	4392.6	4392.8	0.2
516	557119.4	454322.8	Shallow	4384.8	4387.4	2.6
518	560470.7	453790.0	Shallow	4383.7	4383.3	-0.4
520	563607.5	452227.5	Shallow	4385.7	4386.4	0.7
527	561305.9	453222.5	Shallow	4384.1	4383.6	-0.5
335S	560043.0	453065.0	Shallow	4384.0	4383.4	-0.6
509A	561987.9	453522.4	Shallow	4384.4	4383.7	-0.7
528A	560823.0	453396.2	Shallow	4384.0	4383.4	-0.6
529AR	561066.8	453339.1	Shallow	4383.4	4383.5	0.1
PBATR	561341.0	454458.9	Shallow	4382.6	4382.7	0.1
PEI-4	562854.7	452374.0	Shallow	4385.4	4385.6	0.2
WHP-1	560889.0	453424.6	Shallow	4383.9	4383.4	-0.5
WHP-2	560863.3	453723.9	Shallow	4383.8	4383.3	-0.5
WHP-3	560964.2	453721.4	Shallow	4383.8	4383.3	-0.5
WHP-4	561083.8	453680.5	Shallow	4383.9	4383.3	-0.6
102	551848.4	448821.4	Deep	4396.1	4397.0	0.9
103	554265.5	450122.5	Deep	4396.1	4395.4	-0.7
107	556591.1	452320.6	Deep	4393.7	4392.3	-1.4
109	558357.7	453396.2	Deep	4389.3	4388.4	-0.9
130	552950.5	449329.3	Deep	4396.2	4396.5	0.3
133	555371.4	451641.8	Deep	4394.4	4393.4	-1.0
144	557545.2	452188.1	Deep	4391.8	4391.3	-0.5
305	562731.3	450749.0	Deep	4397.4	4398.4	1.0
309	558579.3	452286.0	Deep	4391.7	4389.8	-1.9
313	559738.1	452109.3	Deep	4386.7	4384.2	-2.5
315	560655.8	452006.8	Deep	4390.4	4384.3	-6.1

TABLE 2-3
MONITORING WELLS USED FOR CALIBRATION TARGETS AND MODEL RESIDUALS
(page 4 of 4)

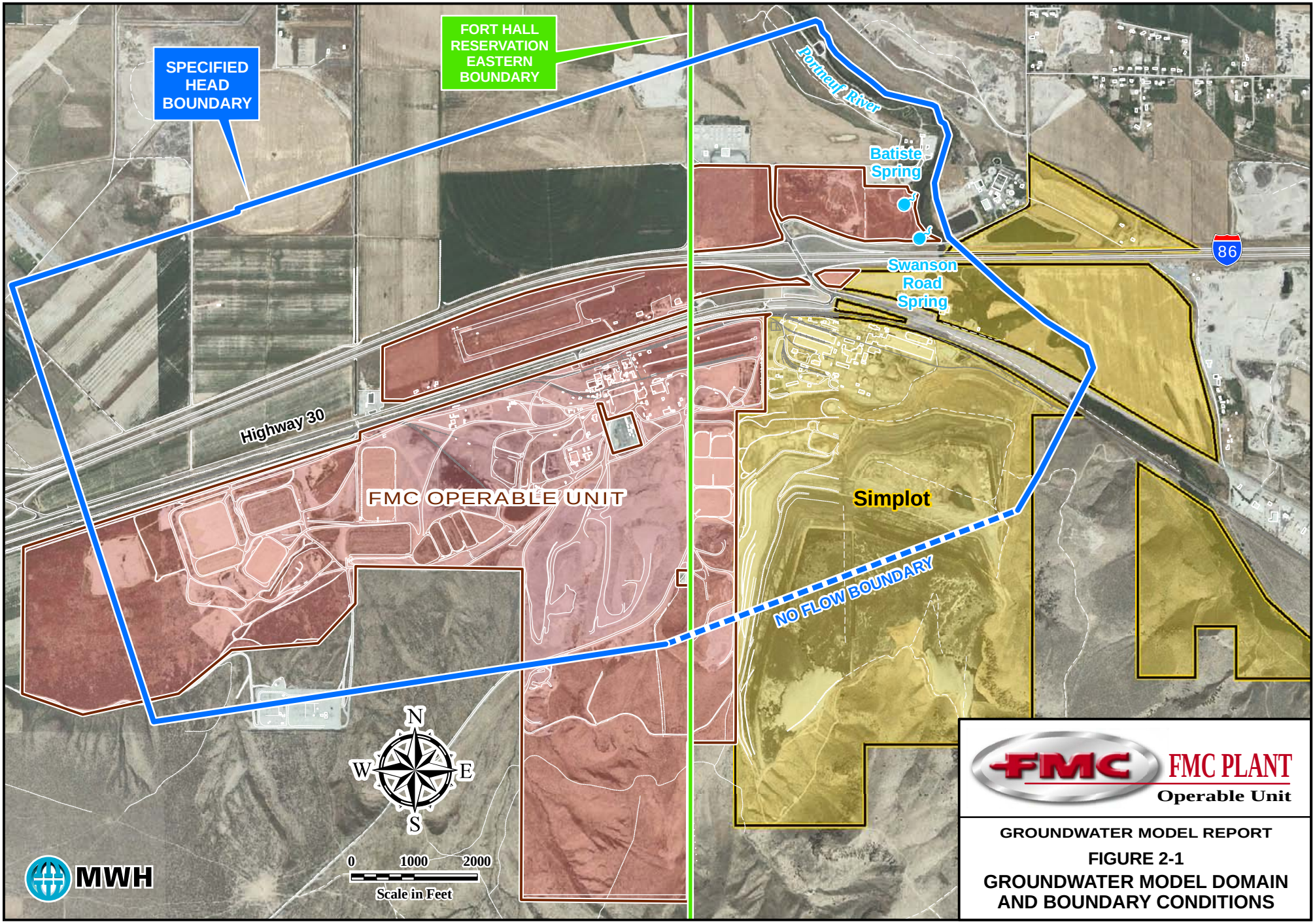
Well ID	Easting	Northing	Aquifer Zone	Observed Water Level	Simulated Water Level	Residual
317	561401.4	452829.8	Deep	4385.1	4383.9	-1.2
319	559843.4	453490.4	Deep	4386.9	4383.6	-3.3
321	562914.8	452335.6	Deep	4385.9	4386.1	0.2
326	560648.8	452523.0	Deep	4384.5	4383.8	-0.7
329	558571.4	453107.0	Deep	4388.5	4388.3	-0.2
330	559129.1	453485.1	Deep	4387.9	4385.3	-2.6
337	560698.9	452460.6	Deep	4385.4	4383.8	-1.6
344	560745.1	452390.1	Deep	4386.1	4383.9	-2.2
346	558629.5	451581.9	Deep	4392.8	4392.6	-0.2
347	560165.6	453326.4	Deep	4384.7	4383.4	-1.3
504	561213.1	454050.5	Deep	4386.7	4383.2	-3.5
508	562013.5	453530.3	Deep	4384.8	4383.8	-1.0
519	560778.4	454358.0	Deep	4385.0	4382.9	-2.1
526	561280.3	453229.8	Deep	4384.5	4383.5	-1.0
335D	560043.5	453065.0	Deep	4385.0	4382.6	-2.4
528B	560823.5	453396.2	Deep	4384.1	4383.4	-0.7
529C	561066.0	453339.1	Deep	4383.2	4383.5	0.3

Notes:
Coordinates are in state plane feet.
Water level elevations are in feet above mean sea level.
Residuals are in feet.

TABLE 2-4
TRANSPORT MODEL PARAMETERS

Parameter	Value
Effective Porosity	35 percent
Bulk Density	1.5 g/cm^3
Dispersivity	
Longitudinal	125 ft
Transverse	12.5 ft
Vertical	1.25 ft
Sorption Coefficients	
Arsenic	2.8 ml/g
Total/Orthophosphate	2.3 ml/g
Potassium	2.8 ml/g
Retardation Factors	
Arsenic	13
Total/Orthophosphate	11
Potassium	13
Pond 8S Source	
Arsenic	0.62 mg/l
Total/Orthophosphate	3,700 mg/l
Potassium	3,000 mg/l
Ponds 3E-6E Source	
Arsenic	0.62 mg/l

FILE *Fig 2-01_GW Model Domain and Boundary Cond_8x11_1209.mxd* *12/15/09*

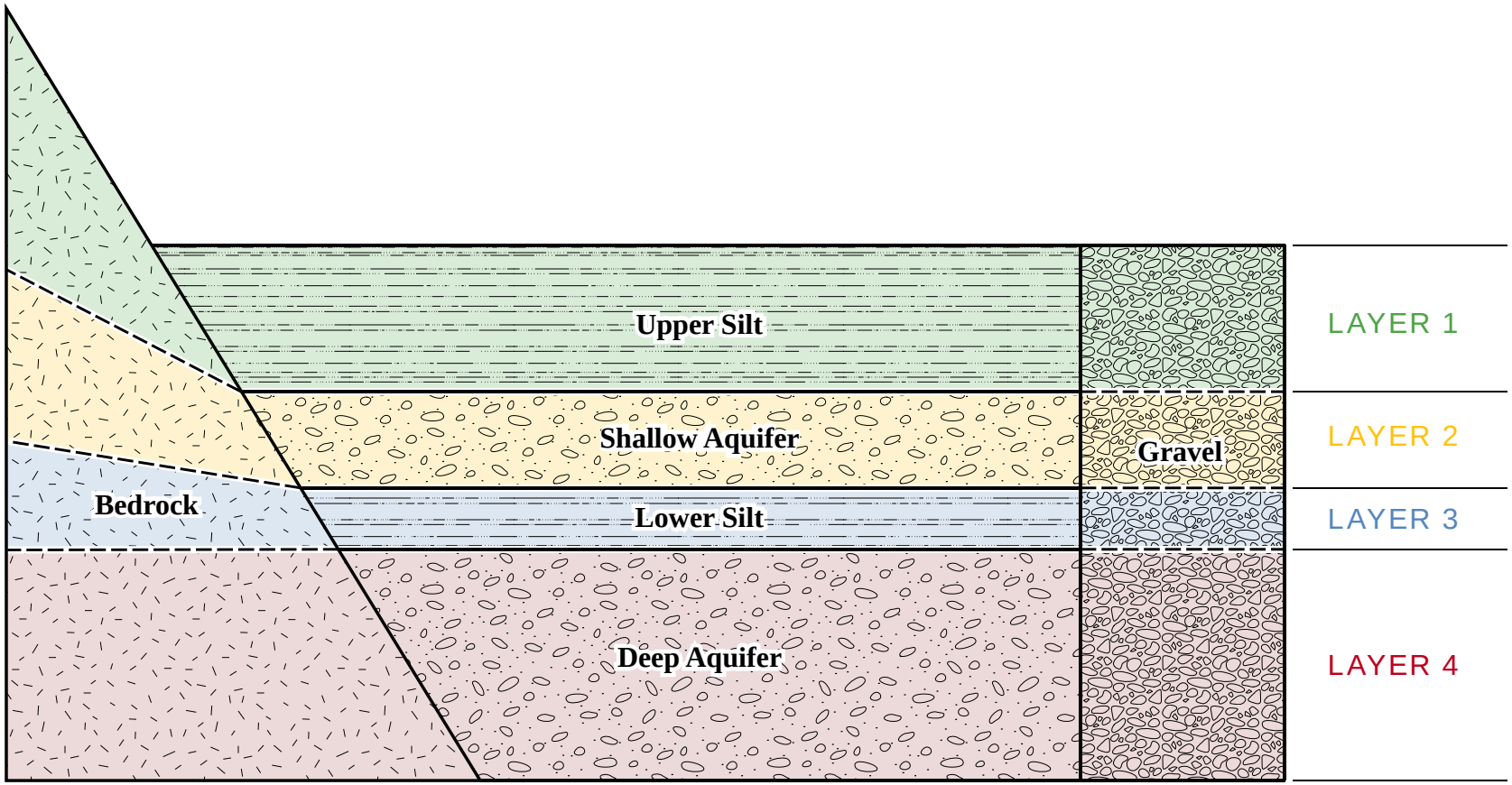


GROUNDWATER MODEL REPORT

FIGURE 2-1

GROUNDWATER MODEL DOMAIN AND BOUNDARY CONDITIONS

FILE *Fig 2-02_Model Layering_1209.ai 12/17/09*



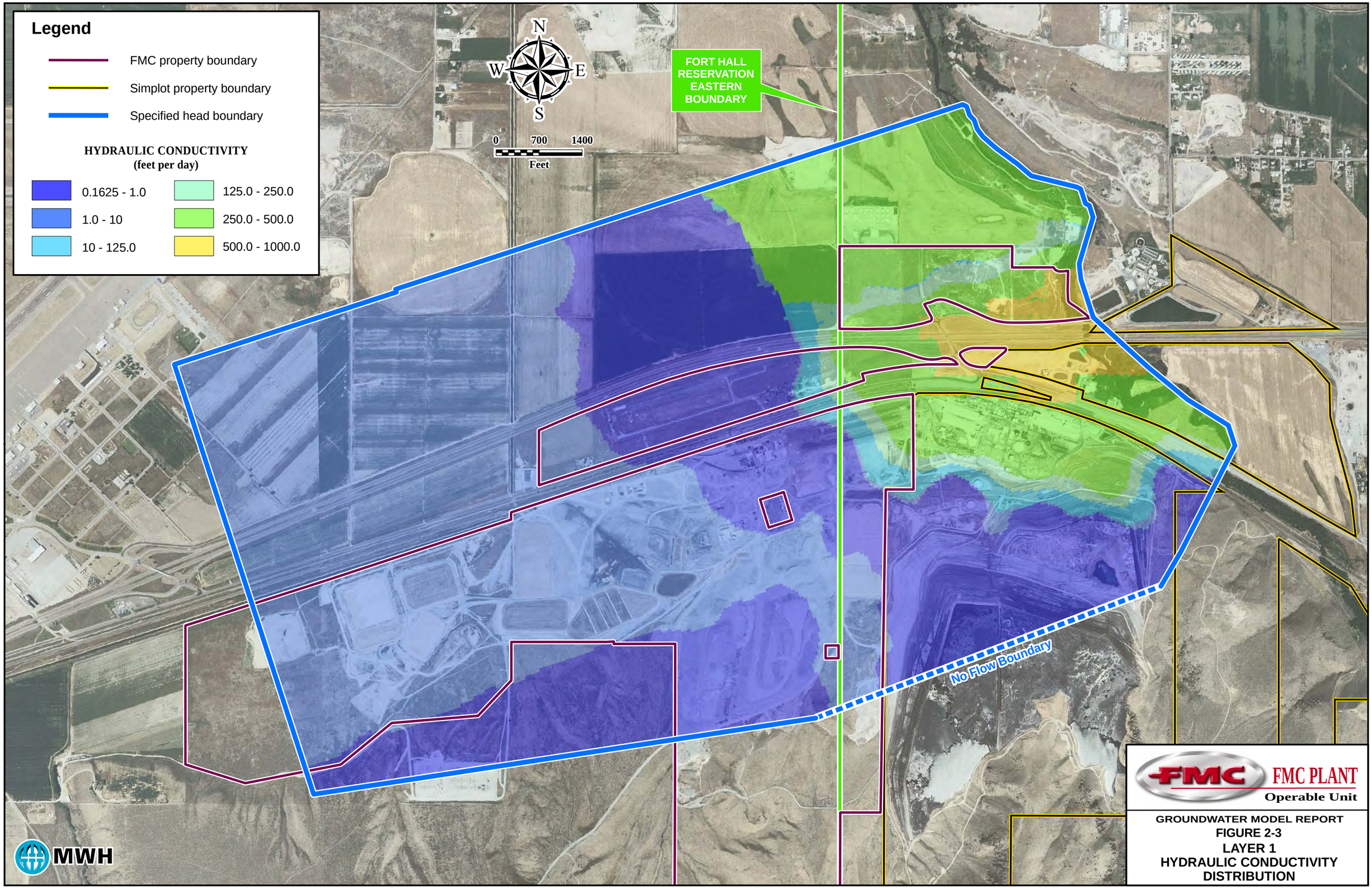
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 2-2

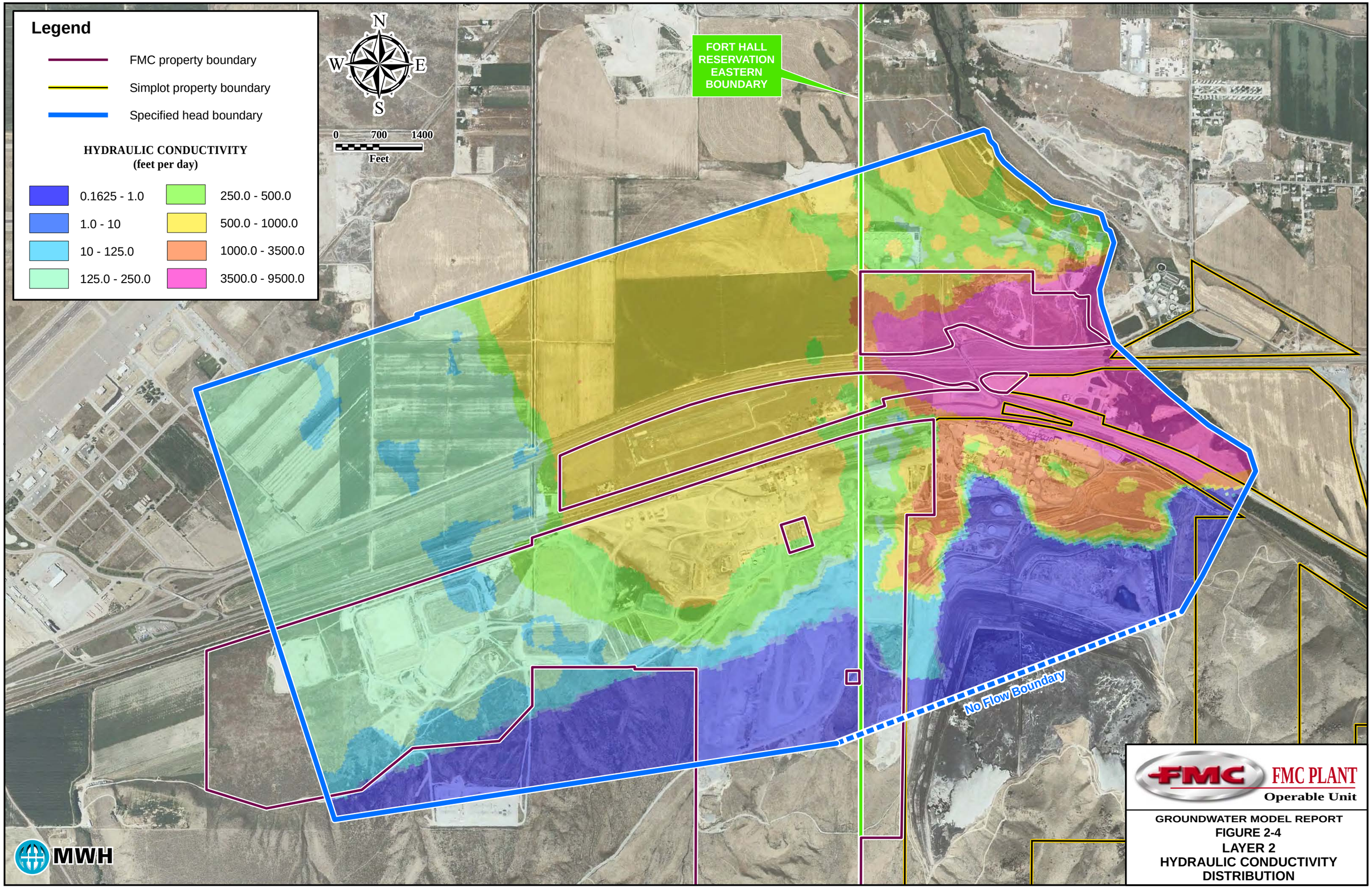
MODEL LAYERING

MWH



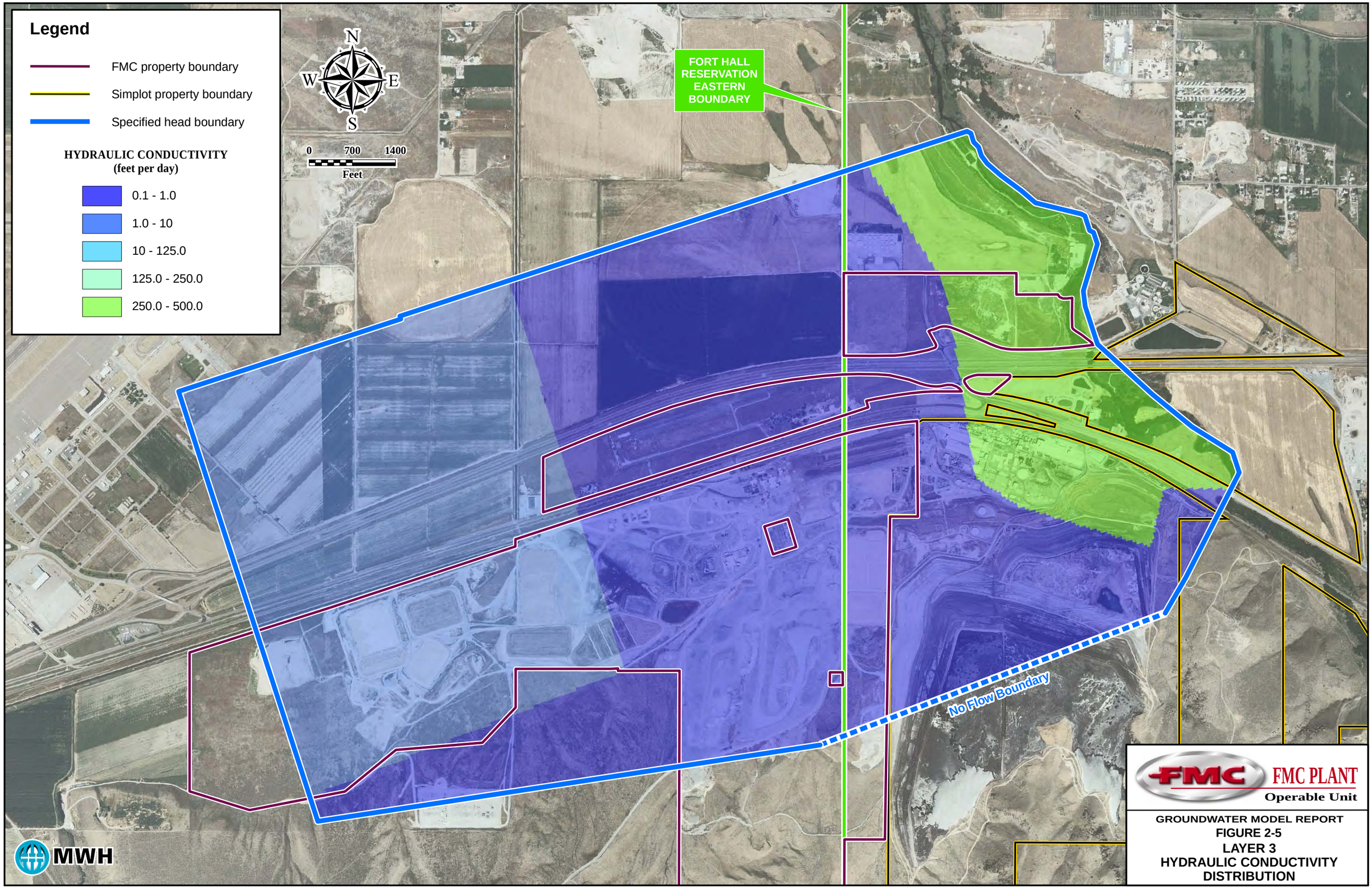
GROUNDWATER MODEL REPORT
FIGURE 2-3
LAYER 1
HYDRAULIC CONDUCTIVITY
DISTRIBUTION

FILE Fig 2-03_Layer_1_Hydraulic Conductivity Distribution_0710.mxd 7Jul10



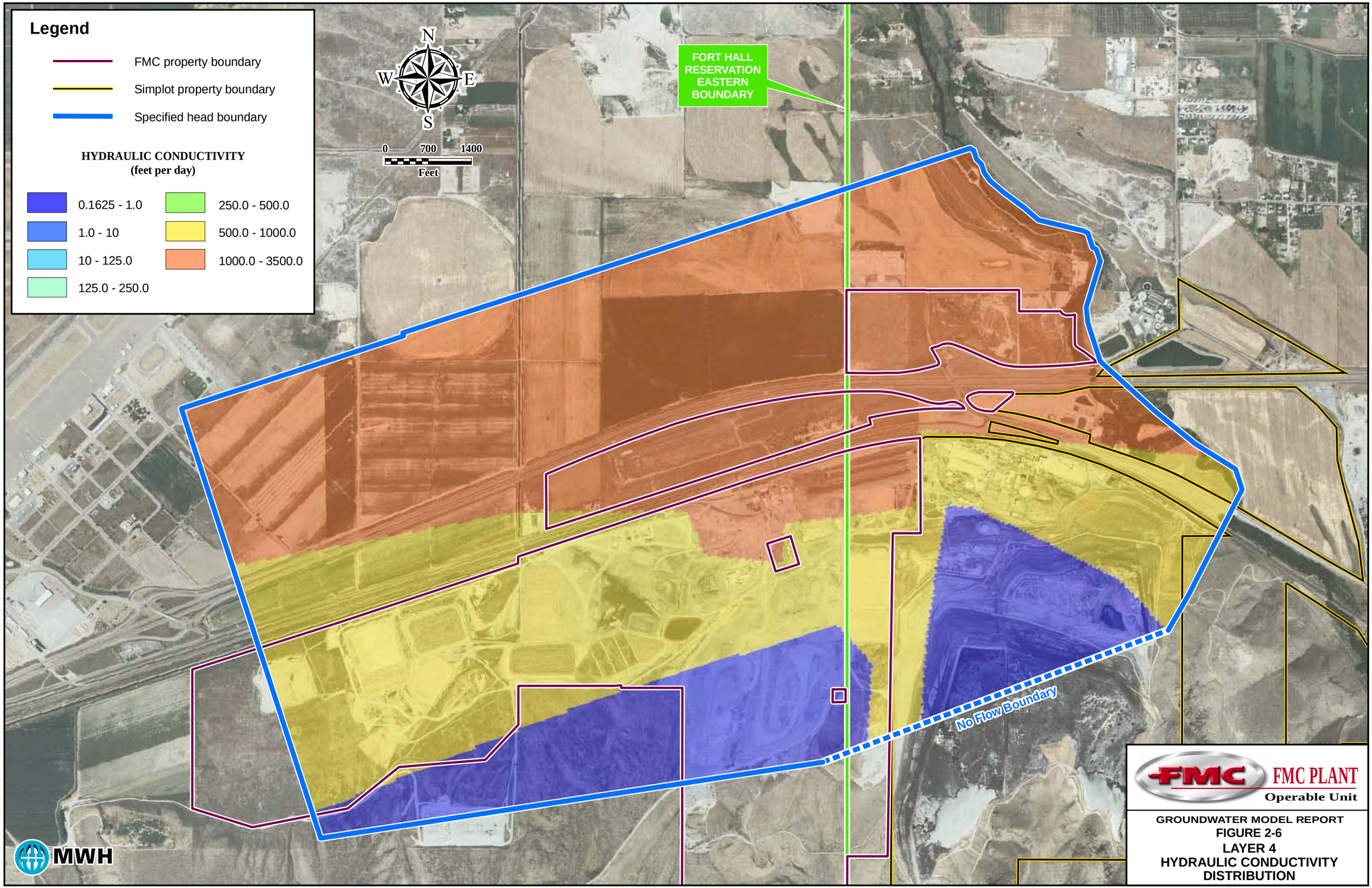
GROUNDWATER MODEL REPORT
FIGURE 2-4
LAYER 2
HYDRAULIC CONDUCTIVITY
DISTRIBUTION

FILE Fig 2-04_Layer_2_Hydraulic Conductivity Distribution_0710.mxd 7Jul10

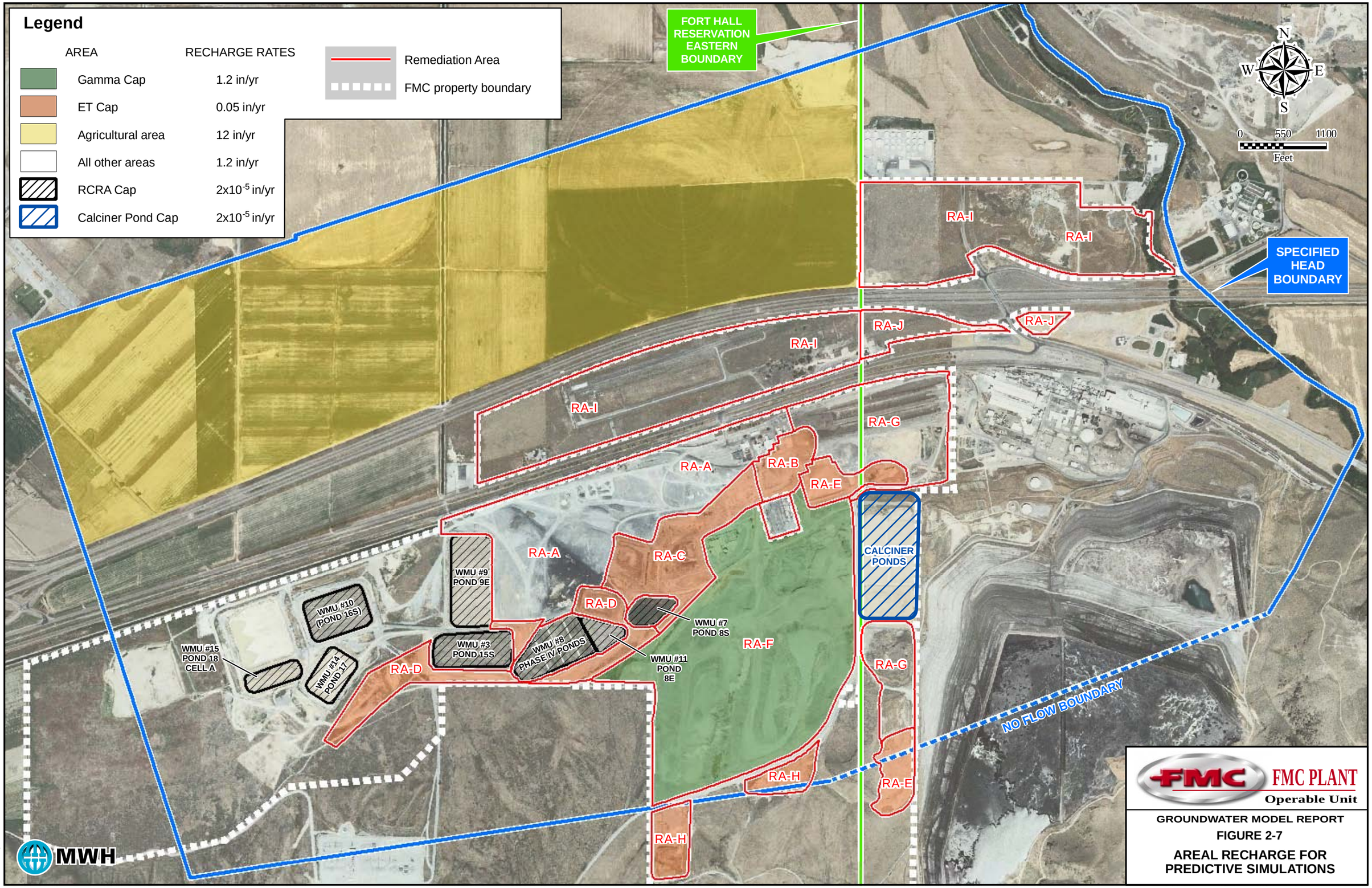


GROUNDWATER MODEL REPORT
FIGURE 2-5
LAYER 3
HYDRAULIC CONDUCTIVITY
DISTRIBUTION

FILE Fig 2-05_Layer_3_Hydraulic Conductivity Distribution_0710.mxd 7Jul10



FILE Fig 2-06_Layer_4_Hydraulic Conductivity Distribution_0710.mxd 7Jul10



GROUNDWATER MODEL REPORT

FIGURE 2-7

AREAL RECHARGE FOR PREDICTIVE SIMULATIONS

FILE Fig 2-07_Areal Recharge for Predictive Simulations_1209.mxd 02/15/10

3.0 RESULTS

3.1 GROUNDWATER FLOW MODEL

3.1.1 Calibration Results

The calibrated steady-state groundwater flow model developed for the site adequately represents flow conditions at the FMC Plant Site, as illustrated by the simulated potentiometric surface contour map and the calibration statistics. The potentiometric contours presented in Figure 3-1 are from the shallow aquifer zone (layer 2); the other layers are not significantly different. Based on errors calculated by comparing simulated water levels to measured values for the 140 calibration targets, the mean error for the calibrated model was -0.4 feet, absolute mean error was 1.1 feet, and root mean squared error (RMSE) was 1.5 feet. The normalized root mean squared error as a percentage of total head change across the model domain (400 feet) was less than 1 percent, indicating an adequate calibration. Residuals calculated from individual calibration targets (water levels from wells) ranged from -6.1 feet (water level underestimated) to 4.2 feet (water level overestimated). Mass balance errors were less than a tenth of one percent. The distribution of residuals is also presented in Figure 3-1. This figure shows that the largest calibration error residuals are concentrated within the Simplot site, an area that will not affect comparative analysis of remedial alternatives and was not a focus of this study.

Simulated flows from the Bannock Range and flows to the Portneuf River, Batiste and Swanson Road Springs were compared to previous estimates, as an additional calibration metric. Flow into the model domain from the Bannock Range was estimated to be 1 to 9 cubic feet per second (cfs) (Bechtel, 1996). Model simulated inflow from the southern boundary was 6 cfs. Estimated flows to the Portneuf River within the model domain were 78 to 111 cfs (Bechtel, 1996). However, these estimates include flow from the eastern side of the river. Assuming 50 percent of this flow comes from each side, the range for comparison to the model would be 36 to 55.5 cfs, because the river forms the eastern boundary of the model domain. Simulated discharge to the river was

approximately 40 cfs, within this range. Combined estimated flow to the springs was approximately 10 cfs, while the simulated spring discharge was 11 cfs.

3.1.2 Flow Model Sensitivity Analysis

A sensitivity analysis was performed for the groundwater flow model to quantify the uncertainty in the model due to estimation of the hydraulic parameters during calibration. Parameters that were varied during the sensitivity analysis were hydraulic conductivity, net areal recharge, river stage, and spring conductance. The results (calibration statistics and flow budgets) of the sensitivity analysis simulations are provided in Table 3-1. The table shows that the flow model is most sensitive to decreases in river stage and hydraulic conductivity and changes to net areal recharge. The model is fairly insensitive to increases in hydraulic conductivity and river stage. Changes to the spring drain package hydraulic conductance had no impact on the model results. Based on the calibration statistics, in particular the RMSE, changes in parameter values performed in the sensitivity analysis generally worsened the calibration, or left it unchanged from the calibrated base case.

3.1.3 Simulation of Remedial Alternatives

For the Alternatives that involved active groundwater extraction (Alternatives 2 and 3), additional flow simulations were performed to provide the underlying flow regimes for the predictive transport simulations. Alternative 1 had no active groundwater extraction. Forward particle tracks for Alternative 1 are presented in Figure 3-2, to show the direction of groundwater flow and for comparison to the pumping alternatives. Particles were placed within the footprint of the arsenic plume (largest plume) in the three uppermost layers and tracked forward in time using the program MODPATH.

The objective of Alternative 2 is to contain contaminated groundwater at the FMC plant site boundary. Many well configurations (alignment and number of wells) and extraction rates were tested, until an optimal configuration was found that minimized extraction rates while still completely capturing on-site contaminated groundwater. The final well

alignment consisted of five wells along the northern plant site boundary, with a total extraction rate of 530 gpm. Containment was assessed by placing MODPATH particles within the footprint of the arsenic plume (largest plume) in the three uppermost layers and tracking them forward. Figure 3-3 presents the extraction well alignment and particle tracking showing containment of on-site contaminated groundwater for Alternative 2. This simulation also included infiltration of 440 gpm (the estimated infiltration rate for Alternative 2 presented in Appendix C) to the western undeveloped area of the FMC Plant Site property to simulate the disposal of treated, extracted groundwater to a percolation/evaporation pond upgradient (west) of the groundwater contamination.

The objective of Alternative 3 is to contain contaminated groundwater at the FMC plant site boundary, with the addition of extraction wells in the western ponds source areas to reduce the total cleanup time for aquifer restoration beneath the FMC Plant Site. Again, many well configurations (alignment and number of wells) and extraction rates were tested, until an optimal configuration was found that minimized extraction rates while completely capturing on-site contaminated groundwater. Alternative 3 included the five extraction wells along the northern plant site boundary as in Alternative 2, though their total extraction rate decreased to 520 gpm, and nine additional extraction wells in potential source areas (Pond 3E - 6E and Pond 8S areas). The four extraction wells placed in the Pond 3E-6E area (now under Ponds 15S and Phase IV Ponds) had a total extraction rate of 60 gpm. The five extraction wells in the Pond 8S area had a total extraction rate of 92 gpm. The total extraction rate for Alternative 3 was 670 gpm. Forward particle tracking was again used to assess containment. Figure 3-4 presents the extraction well alignments and particle tracking showing containment of on-site contaminated groundwater for Alternative 3. This simulation also included infiltration of 560 gpm (the estimated infiltration rate for Alternative 3 is presented in Appendix C) to the southwestern end of the FMC Plant Site property to simulate the disposal of extracted (treated) groundwater to a percolation/evaporation pond upgradient (west) of the groundwater contamination.

3.2 CONTAMINANT TRANSPORT MODEL

3.2.1 Plume Matching Results

Plume matching results indicate that the parameters selected for both the groundwater flow and contaminant transport models were reasonable and provided an acceptable match between observed and predicted plume configurations. Adjustments to retardation factors and dispersivity were necessary to achieve a reasonable match to the observed contaminant distributions. Retardation rates were varied within published ranges (where available, see Section 2.4.2) to more closely match observed distributions. Dispersivity was decreased from initial estimates to 125 feet. The simulated contaminant plumes are similar to the actual contaminant plumes, having achieved reasonable matches of length, width, and assumed timing (see Figures 3-5 through 3-7 for arsenic, total phosphorus/orthophosphate, and potassium, respectively). Simulated and observed concentrations at selected monitoring locations throughout the plumes are presented in Table 3-2. Reasonable matches to point concentrations indicate that the transport model is adequately calibrated.

The overall shape of the model-predicted arsenic plume adequately matches the contoured (observed) plume based on the average of measured values from 2006-2008 (see Figure 3-5). The model-predicted 2008 arsenic plume is shaded, while the observed arsenic plume (contoured with data collected in 2006-2008) is represented with dashed lines (for comparison, see Figure 1-4, which shows the observed arsenic plume in 2008 with shaded concentration zones). Simulated arsenic concentrations at monitoring wells matched observed concentrations within an acceptable range (none exceeding an order of magnitude difference). The greatest differences between the model-simulated and observed arsenic plumes in 2008 were in areas adjacent to the Simplot site. In particular, arsenic concentrations were over predicted downgradient of the Simplot former East Overflow Pond (see Well 527). Arsenic concentrations in the southern portion of the joint fenceline area were underpredicted compared to observed concentrations that reflect the expansion of the Simplot gypsum stack to the south over the 1994 – 2008 timeframe. This is because 1994 concentrations were used to set constant concentration sources

along the Simplot site boundary and maintained at 1994 levels throughout the plume-matching period (1994 through 2008).

The overall shape of the model-predicted total phosphorus/orthophosphate plume adequately matches the contoured plume based on the average of measured values from 2006-2008 (see Figure 3-6). The model-predicted 2008 total phosphorus/orthophosphate plume is shaded, while the observed plume is shown with dashed lines (for comparison, see Figure 1-5, which shows the observed total phosphorus/orthophosphate plume in 2008 with shaded concentration zones). Simulated total phosphorus/orthophosphate concentrations at monitoring wells matched observed concentrations within an acceptable range (none exceeding an order of magnitude difference). Similar to arsenic, the greatest differences between the model-simulated and observed total phosphorus/orthophosphate plumes in 2008 were in areas adjacent to the Simplot site. In particular, concentrations were over predicted downgradient of the Simplot former East Overflow Pond because 1994 concentrations were used to set constant concentration sources along the Simplot site boundary and maintained at 1994 levels throughout the plume-matching period (1994 through 2008).

The overall shape of the model-predicted potassium plume adequately matches the hand-contoured plume based on the average of measured values from 2006-2008 (see Figure 3-7). The model-predicted 2008 potassium plume is shaded, while the observed plume is shown with dashed lines (for comparison, see Figure 1-6, which shows the observed potassium plume in 2008 with shaded concentration zones). Simulated potassium concentrations at monitoring wells matched observed concentrations within an acceptable range (none exceeding an order of magnitude difference). Similar to arsenic, the greatest differences between the model-simulated and observed potassium plumes in 2008 were in areas adjacent to the Simplot site. In particular, potassium concentrations were over predicted downgradient of the Simplot former East Overflow Pond because 1994 concentrations were used to set constant concentration sources along the Simplot site boundary and maintained at 1994 levels throughout the plume-matching period (1994 through 2008).

It is likely that heterogeneities in geochemical and hydrogeologic conditions present at the site contribute to the differences between the observed and simulated contaminant distributions. While actual sorption coefficients may be variable across the site, they were held constant in the model because there was not adequate data to justify attempts to model this heterogeneity. Simplifying assumptions for the adjacent Simplot site also contribute to differences between the observed and simulated plumes. Further, additional monitoring wells and data have been added at the EMF site since the 1993 - 1994 period used for the initial conditions for the plume matching simulations, the additional data and refinements to the definition of the distribution of contaminants is also a source of differences.

3.2.2 Transport Model Sensitivity Analysis

A sensitivity analysis was performed on the calibrated transport model (base case) to assess the model's response to variation in uncertain parameters. Sorption coefficients, dispersivity, and porosity were varied within reasonable ranges.

Sorption coefficients for the three contaminants in groundwater were varied by a factor of five, yielding a range in retardation factors of 2 to 61 for arsenic, 2 to 51 for total phosphorus/orthophosphate, and 2 to 61 for potassium. Increasing the sorption coefficients produced significantly less plume migration than in the base case (calibrated model) and produced plumes that were almost unchanged from their initial conditions. Decreasing the sorption coefficients likewise produced plumes that migrated too far both longitudinally and transversely, and the areas of higher concentration (FMC source areas) were diluted much more than in the base case.

Dispersivity (longitudinal, transverse, and vertical) was varied by a factor of 10, yielding a range of 12.5 to 1250 feet for longitudinal dispersivity. Increasing the dispersivity produced plumes that were more disperse (i.e., larger) than the base case plumes, and also significantly more dilute in areas of higher concentration than the base case plumes. Decreasing the dispersivity produced only slightly less disperse plumes (narrower, with higher concentrations along the plume centerline) than the base case.

Effective porosity was varied by 10 percent giving a range of 25 to 45 percent. These changes produced no significant differences from the base case.

Overall, the calibrated transport model was most sensitive to changes in sorption coefficients and relatively insensitive to changes in dispersivity and porosity. Because of the model's sensitivity to sorption coefficients, additional sensitivity simulations with variable sorption coefficients were performed on the predictive runs. Results of this analysis are presented in Section 3.4.

3.3 PREDICTIVE TRANSPORT

3.3.1 Simulation of Remedial Alternatives

Predictive simulations were performed to compare future contaminant fate under groundwater remedial Alternatives 1, 2 and 3. The simulated alternatives are:

- **Alternative 1** Source controls, institutional controls and long-term monitoring (LTM);
- **Alternative 2** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, and A) discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation / evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.
- **Alternative 3** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, groundwater extraction at specific source areas, and A) on-site treatment and discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation/evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

The predictive simulations assumed all historical source areas have been controlled (closed and/or capped) or are expected to be subject to source controls consistent with the soil remedial alternatives under evaluation in the SFS. They also assumed continued operation of the Simplot gypsum stack at current levels until Simplot completes lining the gypsum stack in 2015 (Simplot, 2009), after which no infiltration from the gypsum stack was simulated. Water supply and extraction system wells at the Simplot site were assumed to operate into the future at their current pumping rates. Concentrations for arsenic, total phosphorus/orthophosphate, and potassium were held constant along the Simplot site boundary. Initial contaminant distributions for the predictive simulations were based on average 2006-2008 observed concentrations. Shallow aquifer zone concentrations were assigned to layers 1 and 2, while deep aquifer zone concentrations were assigned to layers 3 and 4. Simulations were run for 100 years, and the results for three contaminants under Alternatives 1, 2, and 3 are presented in Figures 3-8 through 3-16. Plan-view plumes presented were generated by contouring the vertical maximum concentration from all four model layers. As expected based on site groundwater monitoring data used to calibrate the model, the highest concentrations used to generate the areal extent contours were essentially all in model layers 1 and 2 (the shallow groundwater zone). For comparison of the proposed remedial alternatives, the areal extent (in acres) of groundwater contamination within the FMC Plant Site for each constituent was measured through time so that the relative differences between alternatives could be quantified. In addition, the residual mass of groundwater contamination within the FMC Plant Site was calculated for each constituent based on the sum of the modeled concentration in all four (4) model layers. Both the areal extent and residual mass were calculated for the FMC Plant Site only to minimize effects from the assumptions for the Simplot Plant OU and areas downgradient from both sites toward the Portneuf River. The performance of groundwater Alternatives 1, 2 and 3 were compared based on the percent reduction in areal extent and residual mass for arsenic, total phosphorus / orthophosphate, and potassium in groundwater at the 25, 50 and 100 year time steps.

Results are presented at 25, 50, and 100 years into the future.

Alternative 1. Arsenic, total phosphorus/orthophosphate, and potassium plumes at 25, 50, and 100 years under Alternative 1 (no active groundwater extraction) are presented in Figures 3-8 through 3-10.

Areal Extent

The initial (2008) arsenic plume exceeding the MCL of 0.01 mg/l had an areal extent of approximately 431 acres. Under this alternative, the area of arsenic contamination exceeding the MCL decreased to 384 acres after 25 years, 363 acres after 50 years, and 320 acres after 100 years. This represents a 26 percent decline in the areal extent of the on-site arsenic plume after 100 years.

The initial (2008) total phosphorus/orthophosphate plume exceeding the background concentration of 0.33 mg/l had an areal extent of approximately 292 acres. Under this alternative, the area of total phosphorus/orthophosphate contamination exceeding 0.33 mg/l decreased to 208 acres after 25 years, 175 acres after 50 years, and 112 acres after 100 years. This represents a 62 percent decline in the areal extent of the on-site total phosphorus/orthophosphate plume after 100 years.

The initial (2008) potassium plume exceeding the background concentration of 12.7 mg/l had an areal extent of approximately 420 acres. Under this alternative, the area of potassium contamination exceeding 12.7 mg/l decreased to 336 acres after 25 years, 279 acres after 50 years, and 204 acres after 100 years. This represents a 51 percent decline in the areal extent of the on-site potassium plume after 100 years.

Residual Mass

The model predicted reduction in mass for the arsenic, total phosphorus/orthophosphate, and potassium plumes at 25, 50, and 100 years under Alternative 1 are:

Model Constituent	Predicted Reduction in Contaminant Mass		
	25 Years	50 Years	100 Years
Arsenic	24%	32%	44%
Total phosphorus / Orthophosphate	28%	44%	63%
Potassium	15%	32%	56%

Alternative 2. Alternative 2 included extraction wells placed along the northern site boundary to contain contaminated groundwater. Arsenic, total phosphorus / orthophosphate, and potassium plumes at 25, 50, and 100 years under Alternative 2 are presented in Figures 3-11 through 3-13.

Areal Extent

As in Alternative 1, the initial arsenic plume (concentrations exceeding 0.01 mg/l) had an areal extent of approximately 431 acres. Under Alternative 2, the area of arsenic contamination exceeding 0.01 mg/l decreased to 380 acres after 25 years, 362 acres after 50 years, and 311 acres after 100 years. This represents a 28 percent decline in the areal extent of the on-site arsenic plume after 100 years.

As in Alternative 1, the initial areal extent of the total phosphorus/orthophosphate plume (exceeding 0.33 mg/l) was 292 acres. Under Alternative 2 flow conditions, the area of total phosphorus/orthophosphate contamination exceeding 0.33 mg/l decreased to 205 acres after 25 years, 171 acres after 50 years, and 104 acres after 100 years. This represents a 64 percent decline in the areal extent of the on-site total phosphorus/orthophosphate plume after 100 years.

As in Alternative 1, the initial areal extent of the potassium plume exceeding 12.7 mg/l was 420 acres. Under Alternative 2, the area of potassium contamination exceeding 12.7 mg/l decreased to 319 acres after 25 years, 261 acres after 50 years, and 185 acres after

100 years. This represents a 56 percent decline in the areal extent of the on-site potassium plume after 100 years.

Residual Mass

The model predicted reduction in mass for the arsenic, total phosphorus/orthophosphate, and potassium plumes at 25, 50, and 100 years under Alternative 2 are:

Model Constituent	Predicted Reduction in Contaminant Mass		
	25 Years	50 Years	100 Years
Arsenic	24%	33%	45%
Total phosphorus / Orthophosphate	38%	54%	73%
Potassium	23%	40%	63%

Alternative 3. Alternative 3 included the Alternative 2 extraction wells along the northern site boundary, along with additional extraction wells downgradient of the Pond 3E - 6E and Pond 8S source areas. Arsenic, total phosphorus/orthophosphate, and potassium plumes at 25, 50, and 100 years under Alternative 3 are presented in Figures 3-14 through 3-16.

Areal Extent

As in the other alternatives, the initial condition for arsenic had an areal extent of approximately 431 acres. Under Alternative 3, the area of arsenic contamination exceeding 0.01 mg/l decreased to 375 acres after 25 years, 346 acres after 50 years, and 270 acres after 100 years. This represents a 37 percent decline in the areal extent of the on-site arsenic plume after 100 years.

As in the other alternatives, the initial areal extent of the total phosphorus/orthophosphate plume was 292 acres. Under Alternative 3 flow conditions, the area of total phosphorus/orthophosphate contamination exceeding 0.33 mg/l decreased to 186 acres after 25 years, 138 acres after 50 years, and 62 acres after 100 years. This represents a 79 percent decline in the areal extent of the on-site total phosphorus/orthophosphate plume after 100 years.

As in the other alternatives, the initial areal extent of the potassium plume was 420 acres. Under Alternative 3, the area of potassium contamination exceeding 12.7 mg/l decreased to 306 acres after 25 years, 230 acres after 50 years, and 148 acres after 100 years. This represents a 65 percent decline in the areal extent of the on-site potassium plume after 100 years.

Residual Mass

The model predicted reduction in mass for the arsenic, total phosphorus/orthophosphate, and potassium plumes at 25, 50, and 100 years under Alternative 3 are:

Model Constituent	Predicted Reduction in Contaminant Mass		
	25 Years	50 Years	100 Years
Arsenic	30%	41%	54%
Total phosphorus / Orthophosphate	64%	74%	81%
Potassium	40%	57%	73%

Summary. Graphical comparisons of the effectiveness of each alternative in reducing the areal extent for each contaminant through time are presented in Figures 3-17 through 3-19. Graphical comparisons of the effectiveness of each alternative in reducing the residual mass for each contaminant through time are presented in Figures 3-20 through 3-

22. The percent incremental reduction in areal extent and residual mass for Alternatives 2 and 3 compared to Alternative 1 are summarized below:

Groundwater Alternative	Incremental Reduction Arsenic Areal Extent Vs. Alternative 1			Incremental Reduction Arsenic Mass Vs. Alternative 1		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	-	-	-	-	-	-
2	1%	0%	2%	1%	1%	1%
3	2%	4%	11%	7%	9%	10%

Groundwater Alternative	Incremental Reduction Total P / Orthophosphate Areal Extent Vs. Alternative 1			Incremental Reduction Total P / Orthophosphate Mass Vs. Alternative 1		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	-	-	-	-	-	-
2	1%	1%	2%	10%	10%	10%
3	7%	13%	17%	36%	30%	18%

Groundwater Alternative	Incremental Reduction Potassium Areal Extent Vs. Alternative 1			Incremental Reduction Potassium Mass Vs. Alternative 1		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	-	-	-	-	-	-
2	4%	4%	5%	8%	8%	7%
3	7%	11%	14%	25%	25%	17%

Overall, Alternatives 1 and 2 produced very similar results when comparing cleanup performance based on the areal extent within the FMC Plant Site (within 2 to 5 percent for all three constituents after 100 years). However, Alternative 2 provides an increment of contaminant mass removal (1 to 10 percent less residual mass for all three constituents) compared to Alternative 1. As expected, Alternative 3 achieves better cleanup performance (9 to 15 percent over Alternative 2 when comparing plume areal extent after 100 years) and mass removal (8 to 10 percent over Alternative 2 after 100 years) through the addition of source area extraction wells, particularly the extraction area downgradient from former Pond 8S where the highest total phosphorus / orthophosphate and potassium concentrations are present in groundwater at the FMC

Plant Site. However, with respect to arsenic, the risk-driving groundwater COC and over-riding groundwater ARAR, Alternative 3 provides only a marginal improvement in reducing aerial extent and mass removal compared to Alternative 2 (9 percent compared to Alternative 2 after 100 years).

None of the alternatives are predicted to meet the groundwater restoration RAO within 100 years.

3.4 SENSITIVITY ANALYSIS ON PREDICTIVE SIMULATIONS

A sensitivity analysis on the predictive transport simulations was also performed, to further quantify the effects of uncertainty in transport parameters on the remedial alternatives. Because the results of the sensitivity analysis on plume matching showed that the transport model was fairly insensitive to variation in dispersivity and porosity, only the sorption coefficients were varied in this analysis**.** The results of the previous sensitivity analysis also showed that the range in sorption coefficients (factor of five) did not produce a reasonable match to observed concentration distributions, so a narrower range (factor of two) of sorption coefficients was employed.

Lowering the sorption coefficients by a factor of two allowed for less retarded transport of constituents. This increased mobility increased the effectiveness (by a factor of approximately 1.05 to 1.4) of the remedial alternatives. However, RAOs were not attained for any of the constituents within the FMC Plant Site after 100 years.

Increasing the sorption coefficients by a factor of 2 obviously had the opposite effect, increasing the retardation of the constituents and decreasing the effectiveness of the remedial alternatives.

3.5 MODEL LIMITATIONS

This model was developed specifically to compare the relative effectiveness of remedial alternatives within the FMC plant site. Simplifying assumptions documented above were

made concerning hydraulic and contaminant loading from the neighboring Simplot site that negate its use as an absolute predictor of cleanup times for the entire EMF Superfund Site and prevent the estimation of impacts to the Portneuf River. In addition, the model's sensitivity to variation in sorption parameters indicates that further study to decrease uncertainty in these parameters would be necessary to improve absolute cleanup time predictions.

A more complex set of assumptions for the Simplot site and possible model refinement would be necessary to make EMF Superfund Site cleanup time predictions and to assess impacts to the Portneuf River.

TABLE 3-1
GROUNDWATER FLOW MODEL SENSITIVITY ANALYSIS

Model Run	ME (feet)	MAE (feet)	RMSE (feet)	Normalized RMSE	Flow to River (cfs)	Flow to Springs (cfs)	Flow From Bannock Range (cfs)
Base Run	-0.42	1.09	1.48	--	40	11	6
K x 2	-0.35	1.05	1.54	1.04	83	22	12
K / 2	-0.53	1.48	2.17	1.47	32	5	3
River + 3 ft	0.80	1.42	1.84	1.24	27	16	6
River - 3 ft	-1.56	2.40	3.80	2.57	60	5	6
Spring Conductance x 10	-0.42	1.09	1.48	1.00	40	11	6
Spring Conductance / 10	-0.42	1.09	1.48	1.00	40	11	6
Recharge x 2	-0.04	1.19	1.90	1.28	41	11	6
Recharge / 2	-0.59	1.17	1.68	1.14	40	11	6

Notes:
ME = Mean Error
MAE = Mean Absolute Error
RMSE = Root Mean Squared Error
Normalized RMSE = RMSE from run divided by RMSE from base run
CFS = Cubic Feet Per Second

TABLE 3-2
SIMULATED VERSUS OBSERVED CONCENTRATIONS IN SELECTED MONITORING WELLS

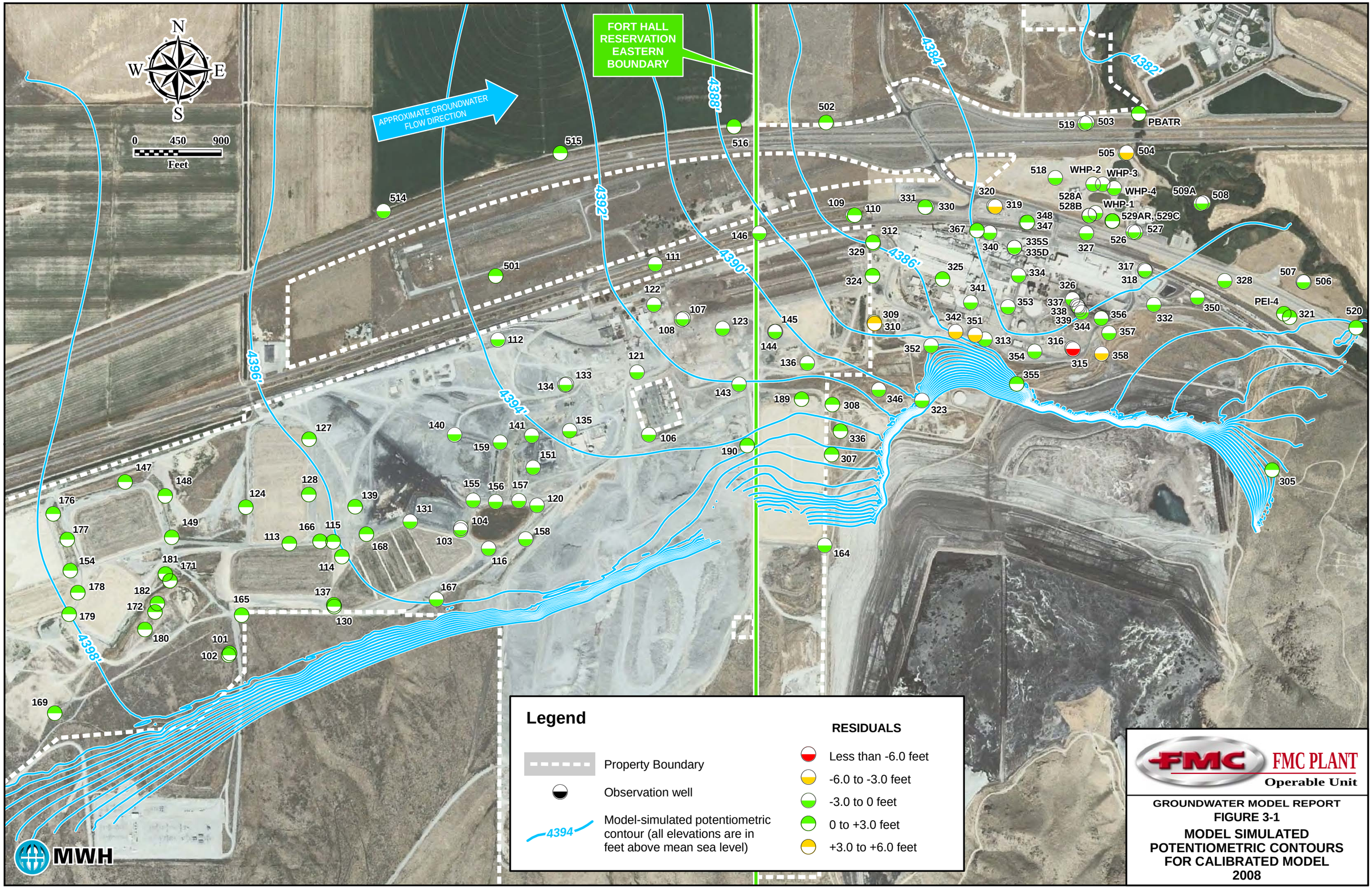
Well ID	Observed Arsenic (mg/l)	Simulated Arsenic (mg/l)	Observed Total/Orthophosphate (mg/l)	Simulated Total/Orthophosphate (mg/l)	Observed Potassium (mg/l)	Simulated Potassium (mg/l)
WELL-115	0.26	0.14	2	4	12	13
WELL-156	0.16	0.12	278	330	1305	1045
WELL-134	0.1	0.07	20	46	153	145
WELL-122	0.06	0.06	18	13	126	130
WELL-123	0.24	0.12	1	5	26	37
WELL-136	0.33	0.2	112	45	54	31
WELL-110	0.05	0.09	3	19	25	39
WELL-146	0.03	0.14	1	3	46	98
TW-9S	0.03	0.02	3	5	58	72
WELL-112	0.01	0.02	1	1	7	14
WELL-515	0.01	0	0	0	9	2
TW-11S	0	0.01	1	1	5	20

TABLE 3-3
REMEDIAL ALTERNATIVE EXTRACTION RATES

Alternative	Groundwater Extraction Zone	Total Simulated Extraction Rate (gpm)	Individual Well Extraction Rates (gpm)				
			1	2	3	4	5
1	--	--	--	--	--	--	--
2	Site Boundary	531	127	94	80	110	120
3	Site Boundary	520	120	91	80	109	120
	Ponds 3E-6E Source Area	60	19	13	13	15	--
	Pond 8S Source Area	92	20	17	19	17	19
	Total	672					

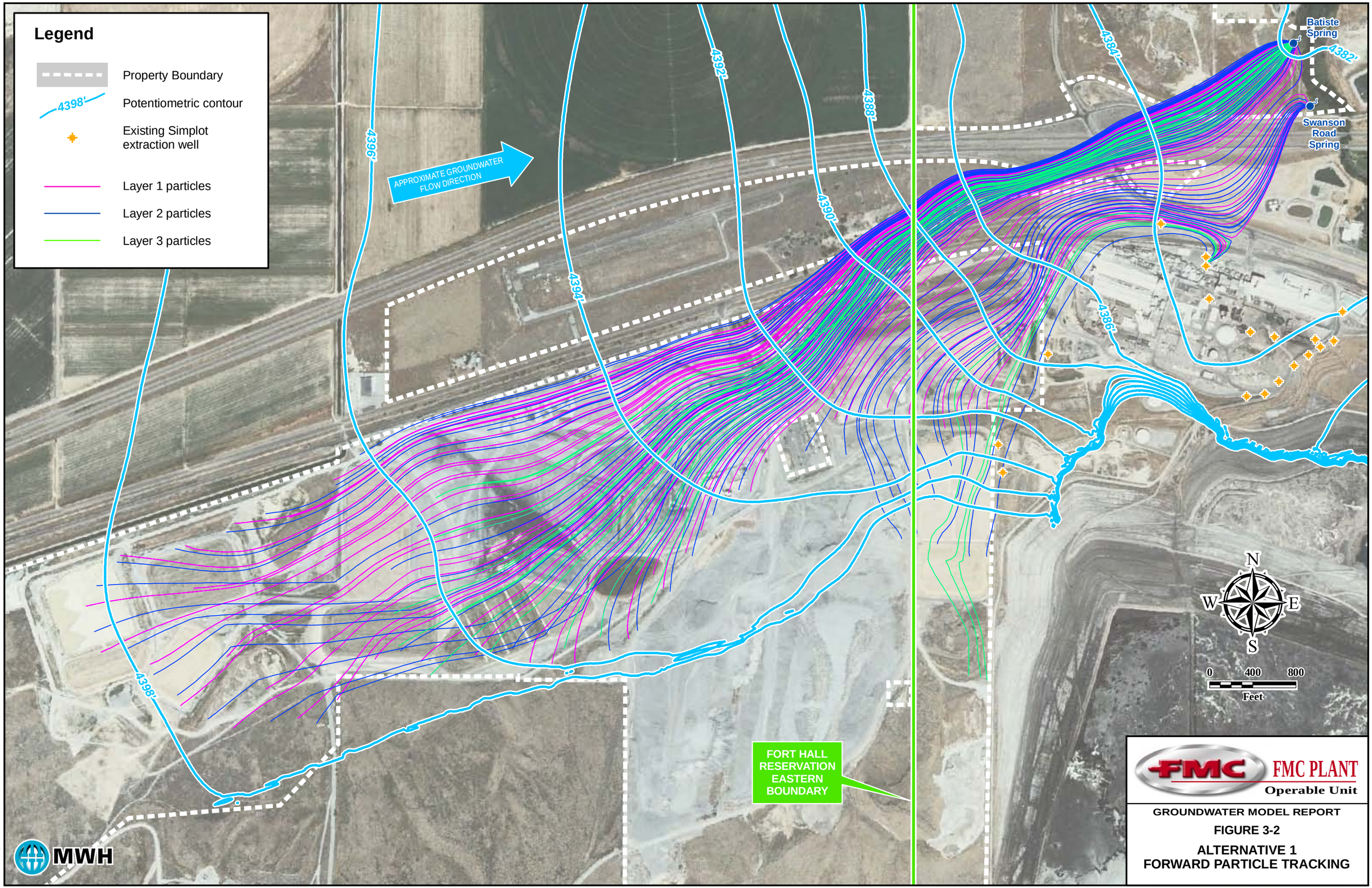
TABLE 3-4
TRANSPORT MODEL SENSITIVITY ANALYSIS

Simulation	Sensitivity Run	Result
Calibrated Transport Model	Sorption Coefficient (K_d) x 5	too little plume migration, very little change from initial conditions
	Sorption Coefficient (Kd) / 5	too much plume migration and dilution of higher concentration areas
	Dispersivity x 10	overly disperse plumes, poor simulation of higher concentration areas
	Dispersivity / 10	slightly less disperse plumes
	Porosity + 10%	no significant change from the calibrated plumes
	Porosity – 10%	no significant change from the calibrated plumes
Predictive Transport Model (Alternative 1)	Sorption Coefficient (K_d) x 2	decreased effectiveness of remedial alternatives
	Sorption Coefficient (Kd) / 2	increased effectiveness of remedial alternatives (RAOs not met within 100 years)
Predictive Transport Model (Alternative 2)	Sorption Coefficient (K_d) x 2	decreased effectiveness of remedial alternatives
	Sorption Coefficient (Kd) / 2	increased effectiveness of remedial alternatives (RAOs not met within 100 years)
Predictive Transport Model (Alternative 3)	Sorption Coefficient (K_d) x 2	decreased effectiveness of remedial alternatives
	Sorption Coefficient (Kd) / 2	increased effectiveness of remedial alternatives (RAOs not met within 100 years)



GROUNDWATER MODEL REPORT
FIGURE 3-1
MODEL SIMULATED POTENTIOMETRIC CONTOURS FOR CALIBRATED MODEL 2008

FILE Fig 3-01_Model Sim Potentiometric Head Contours_2008.mxd 1/27/10



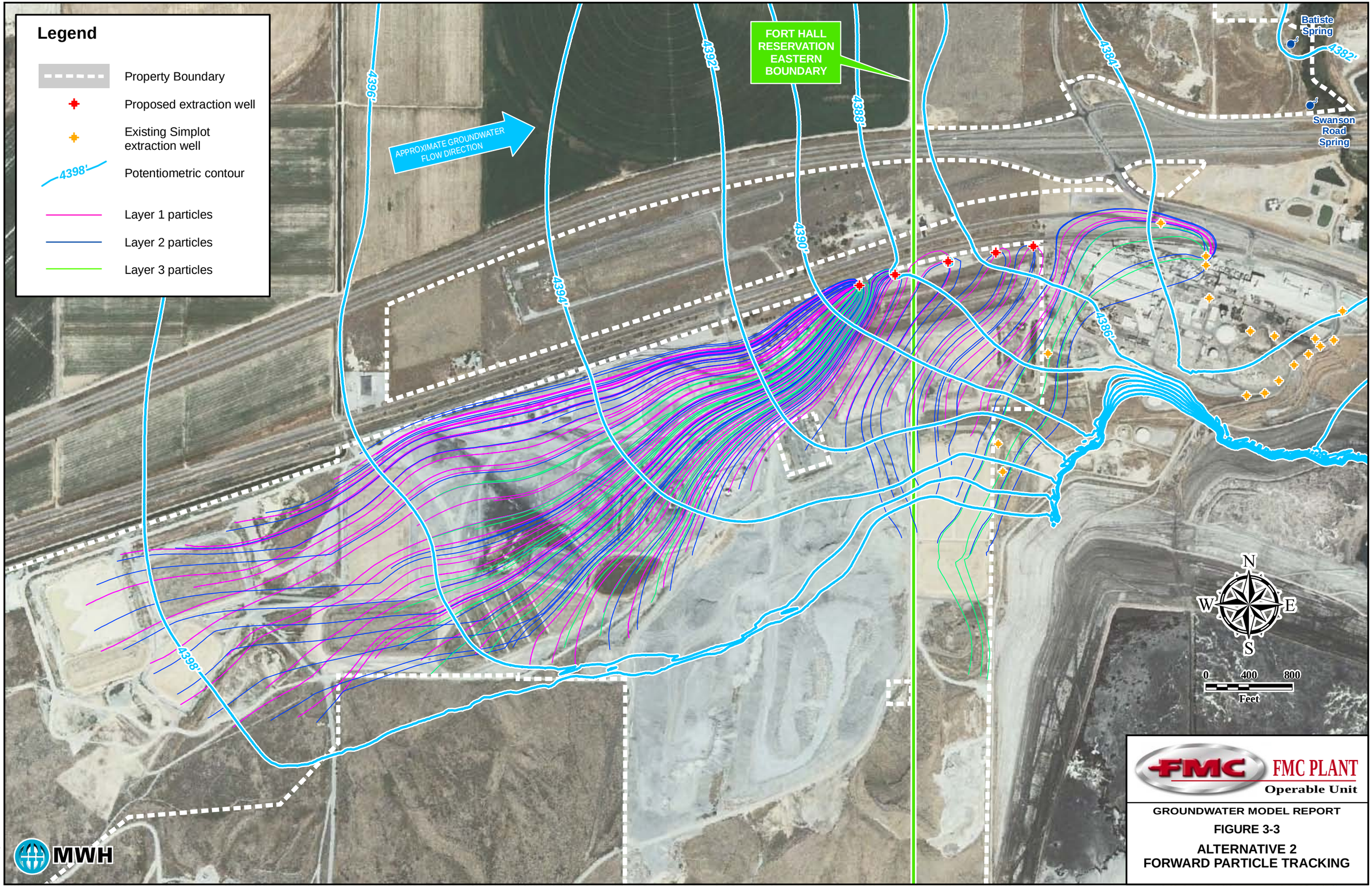
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-2

ALTERNATIVE 1
FORWARD PARTICLE TRACKING

FILE Fig 3-02_Alternative 1 Particle Tracking_0210.mxd 2/17/10



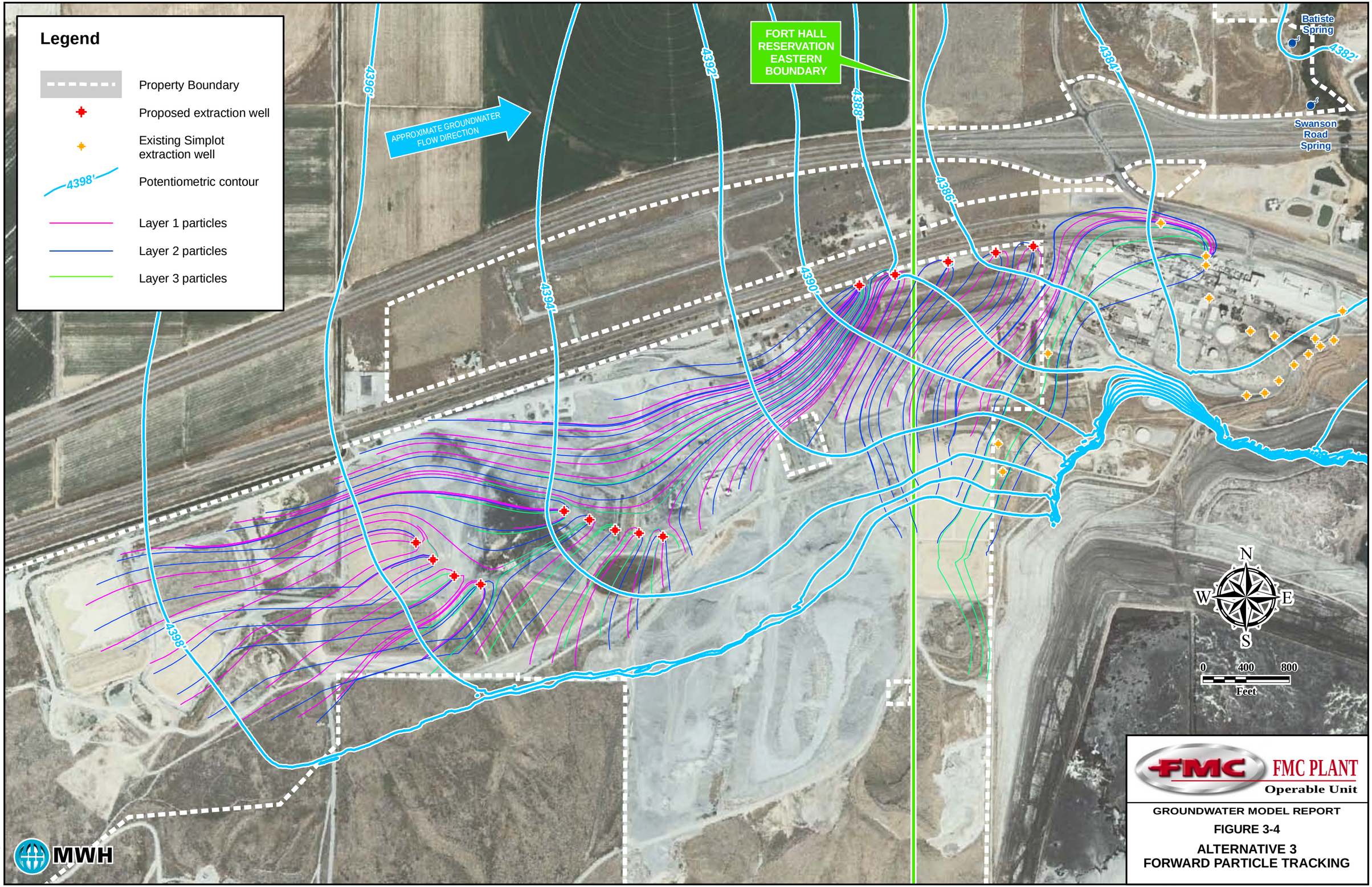
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-3

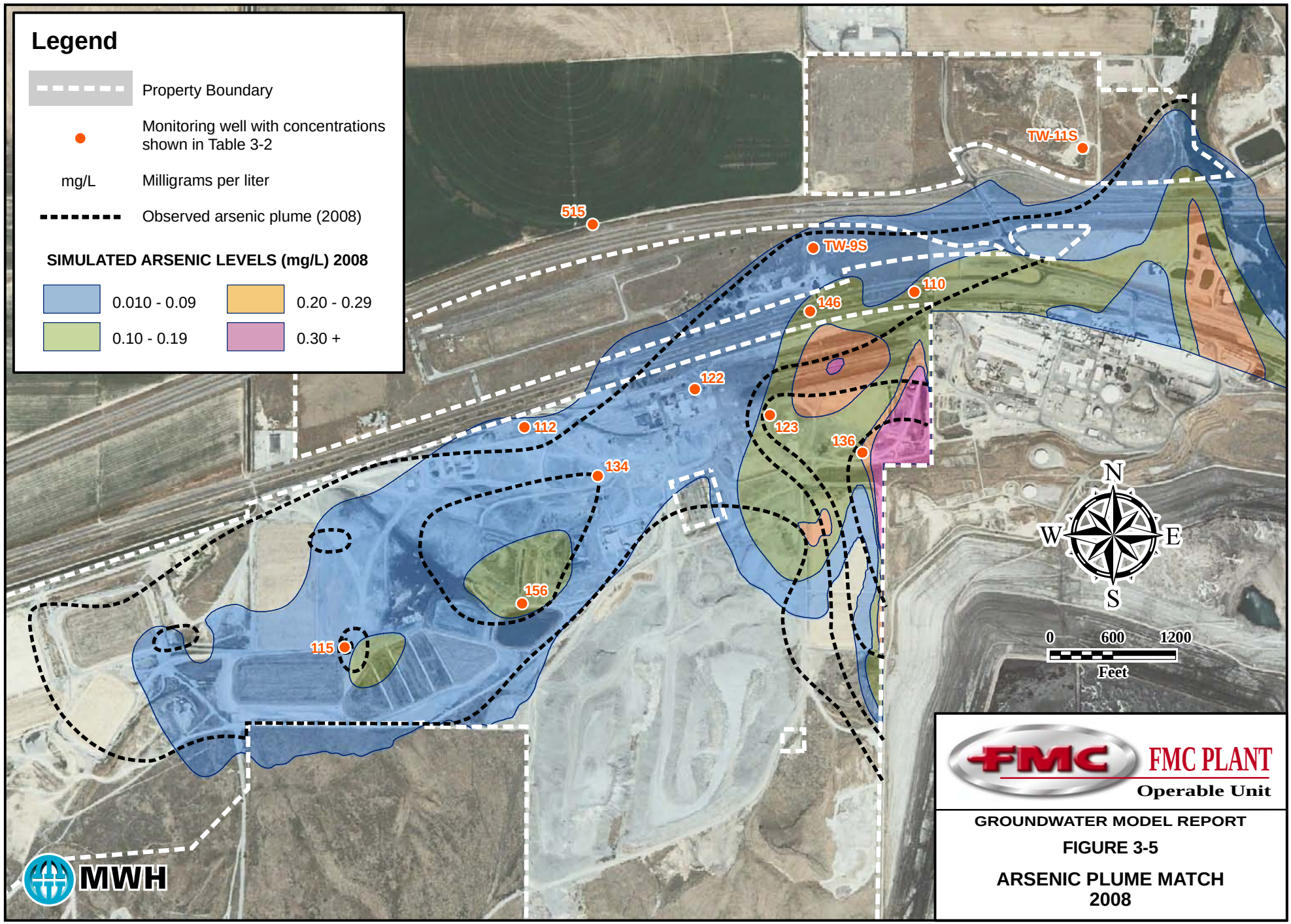
ALTERNATIVE 2
FORWARD PARTICLE TRACKING

FILE Fig 3-03_Alternative 2 Particle Tracking_0210.mxd 2/17/10



FILE Fig 3-04_Alternative 3 Particle Tracking_0210.mxd 2/17/10

FILE *Fig 3-05_Arsenic Plume Match_8x11_0710.mxd* *9Jul10*

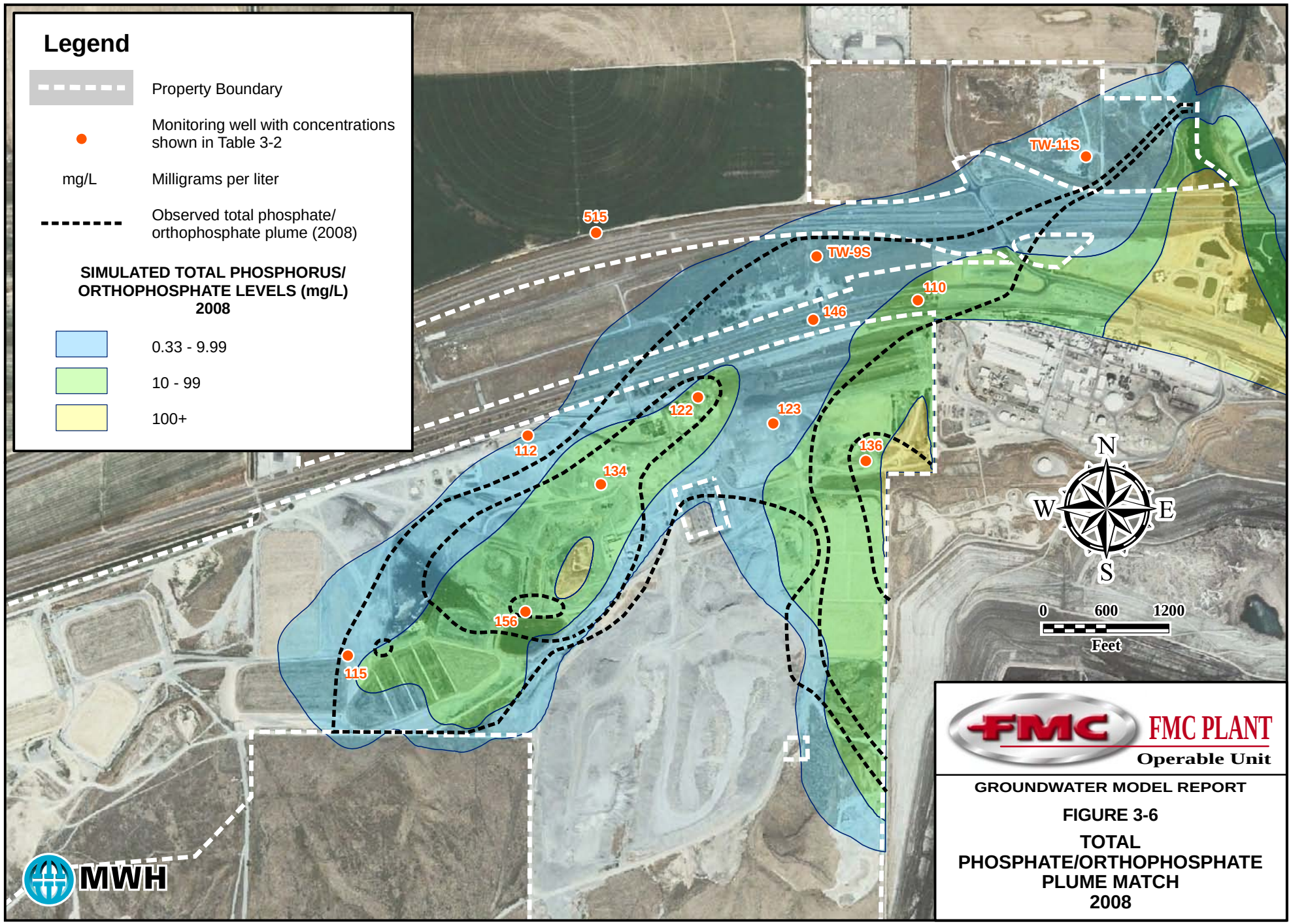


GROUNDWATER MODEL REPORT

FIGURE 3-5

ARSENIC PLUME MATCH
2008

FILE *Fig 3-06_Orthophosphate Plume Match_8x11_0210.mxd* *2/17/10*



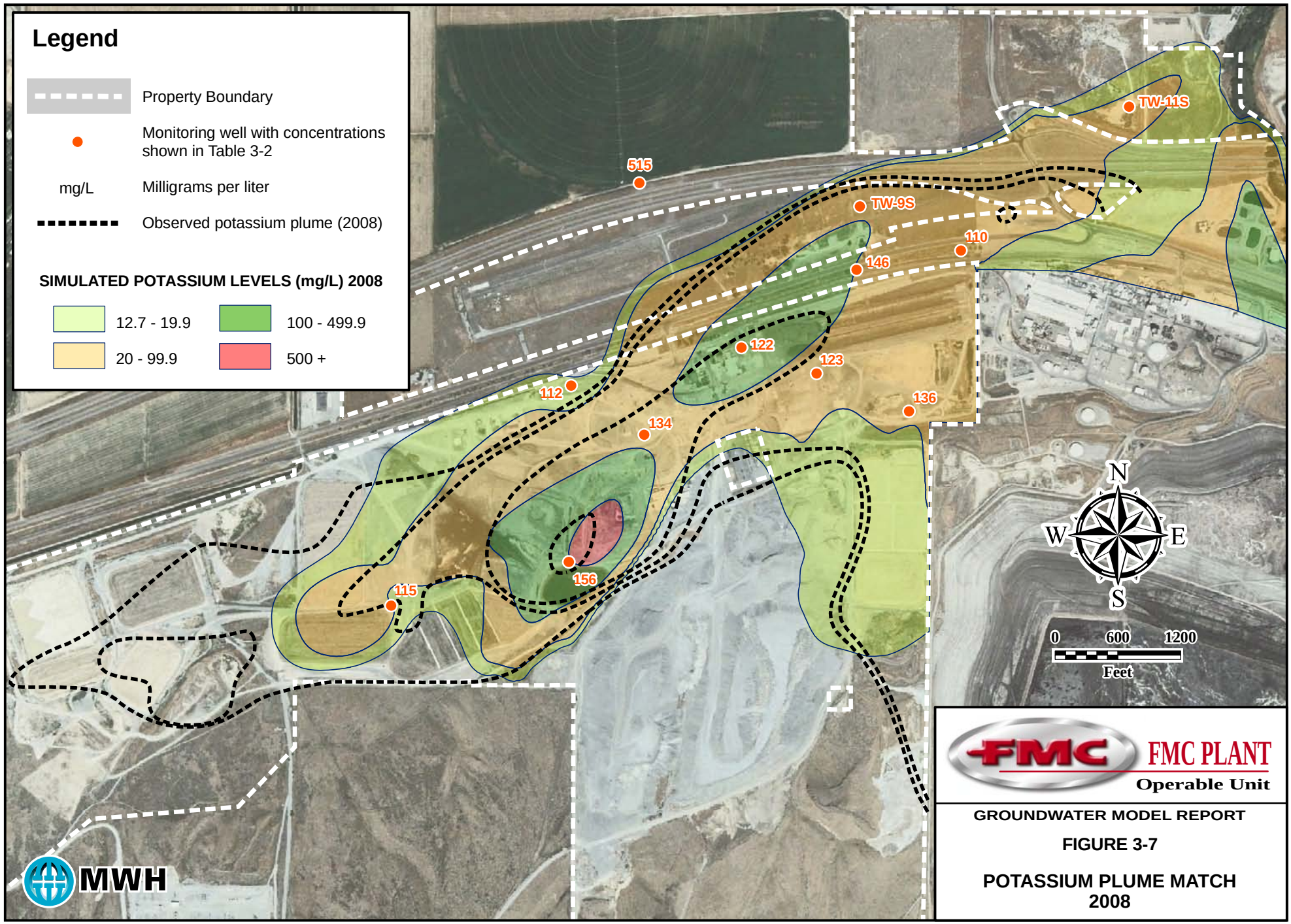
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-6

TOTAL PHOSPHATE/ORTHOPHOSPHATE PLUME MATCH 2008

FILE *Fig 3-07_Potassium Plume Match_8x11_0210.mxd* *2/17/10*



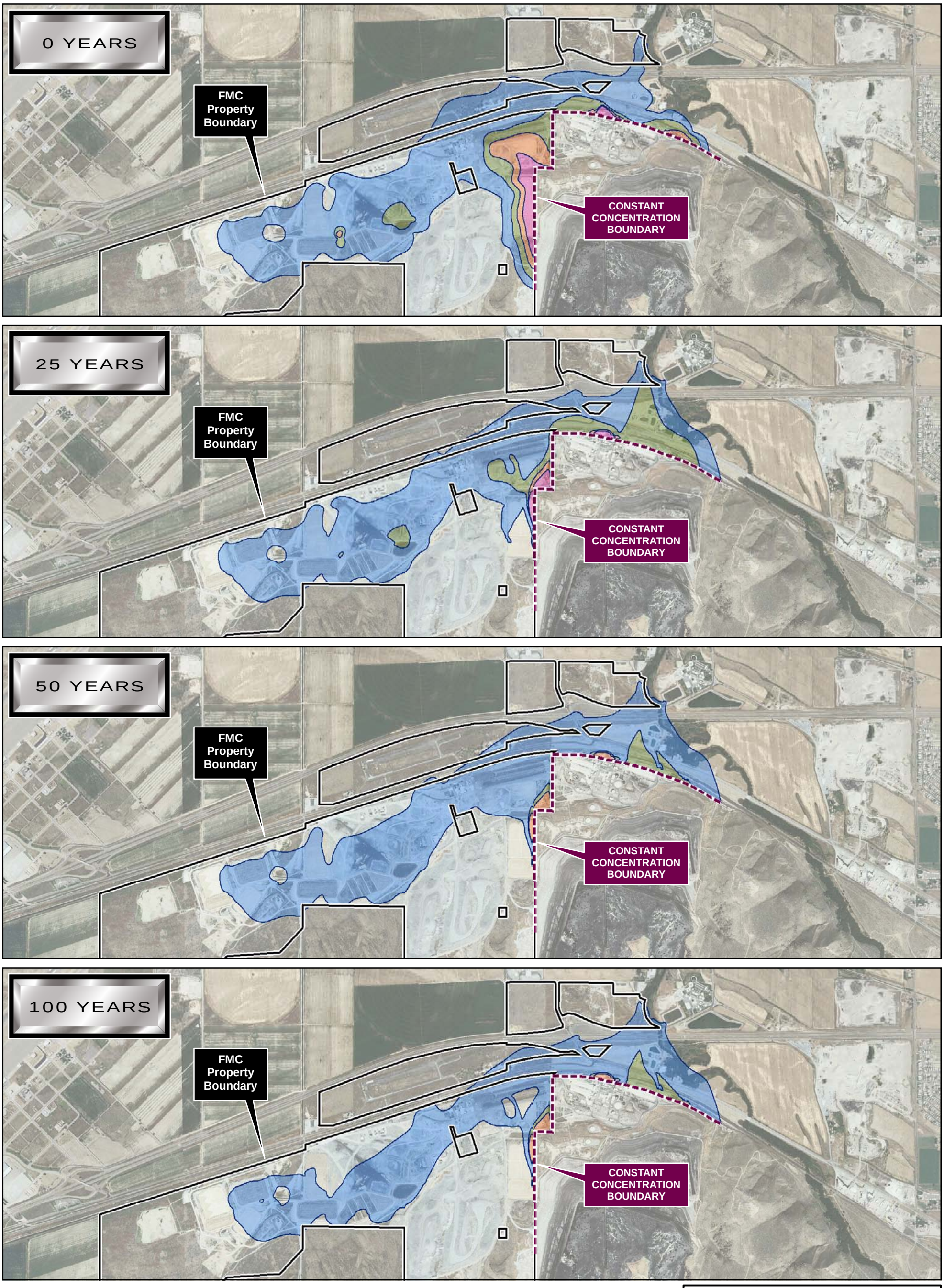
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-7

POTASSIUM PLUME MATCH
2008

FILE *Fig 3-08_Alt1_ModelPredicted_Arsenic_0710.mxd 9Jul10*



ARSENIC LEVELS
(mg/L)

- 0.010 - 0.09
- 0.10 - 0.19
- 0.20 - 0.29
- 0.30 +

mg/L Milligrams per liter

N
W E
S

0 1200 2400
Feet

MWH

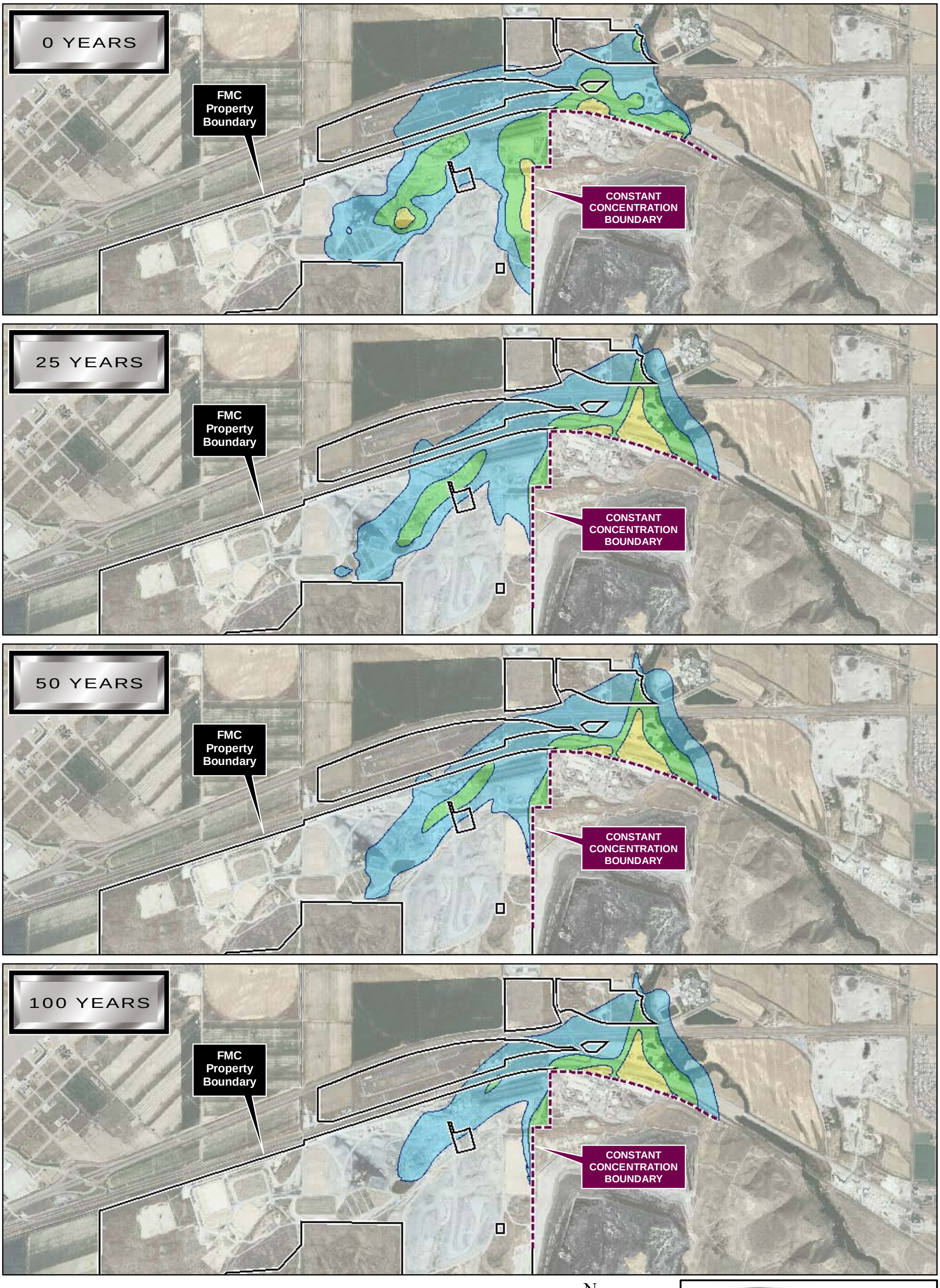
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-8

ALTERNATIVE 1
MODEL-PREDICTED
ARSENIC PLUME

FILE *Fig 3-09_Alt1_ModelPredicted_Orthophosphate_0210.mxd 2/17/10*



TOTAL/ORTHOPHOSPHATE LEVELS (mg/L)

- 0.33 - 9.99
- 10 - 99
- 100+

mg/L Milligrams per liter

N W E S

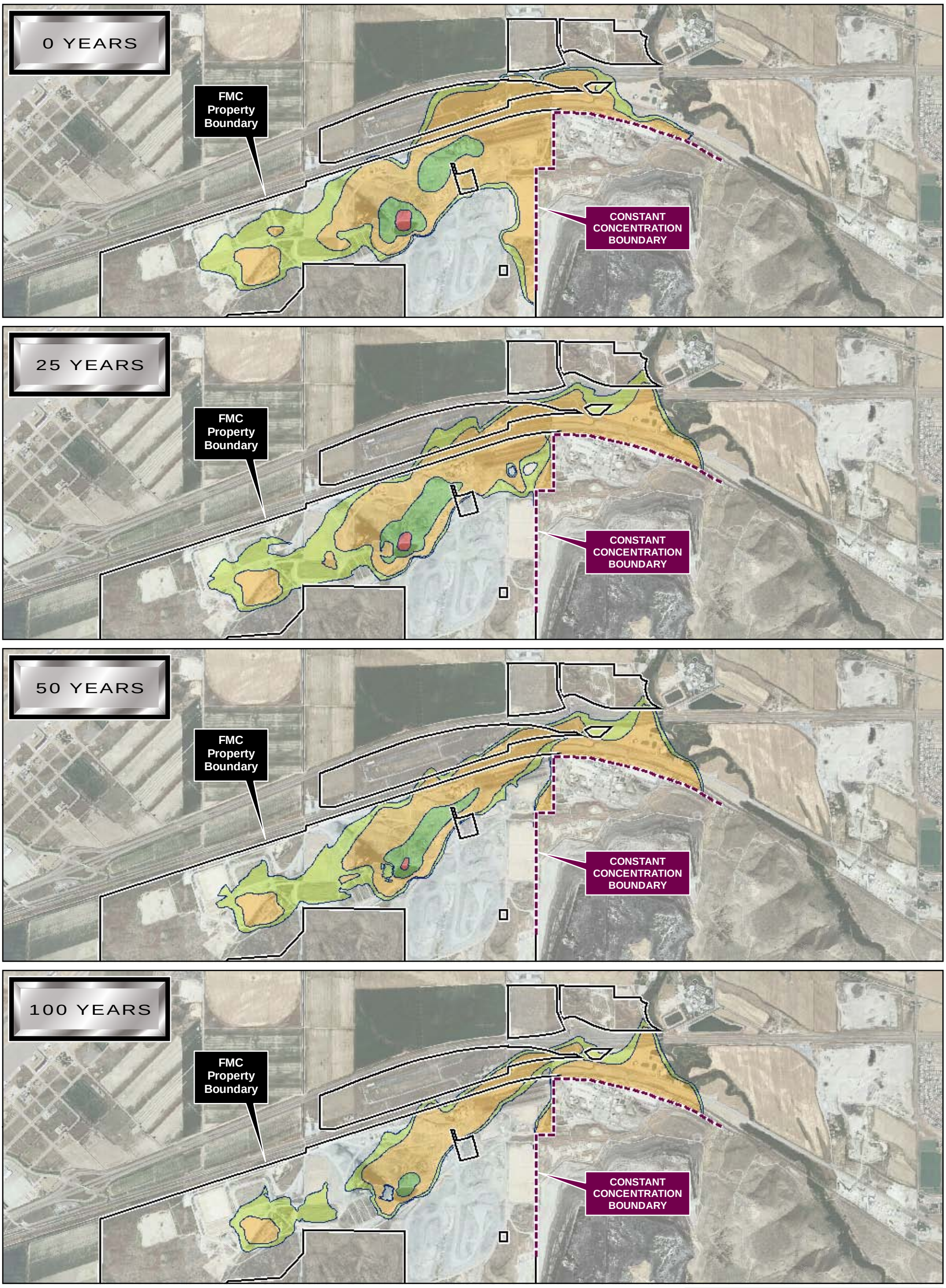
0 1200 2400
Feet

MWH

FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT
FIGURE 3-9
ALTERNATIVE 1
MODEL-PREDICTED
TOTAL/ORTHOPHOSPHATE PLUME

FILE *Fig 3-10_Alt1_ModelPredicted_Potassium_0210.mxd 2/17/10*



POTASSIUM LEVELS
(mg/L)

- 12.7 - 19.9
- 20 - 99.9
- 100 - 499.9
- 500+

mg/L Milligrams per liter

N
W E
S

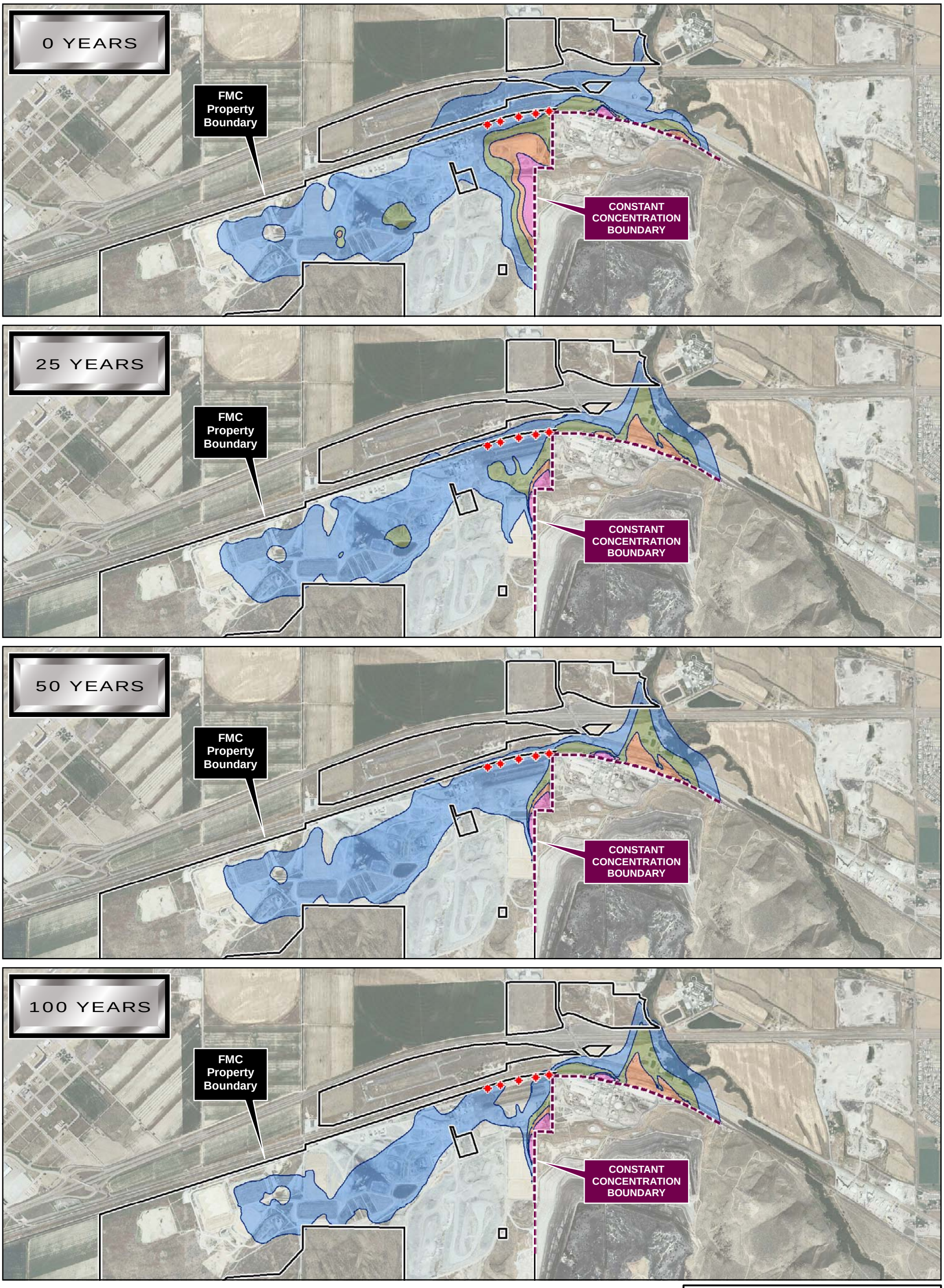
0 1200 2400
Feet

MWH

FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT
FIGURE 3-10
ALTERNATIVE 1
MODEL-PREDICTED
POTASSIUM PLUME

FILE *Fig 3-11_Alt2_ModelPredicted_Arsenic_0710.mxd 9Jul10*



ARSENIC LEVELS (mg/L)

- 0.010 - 0.09
- 0.20 - 0.29
- 0.10 - 0.19
- 0.30 +

Extraction well

mg/L Milligrams per liter

N W E S

0 1200 2400 Feet

MWH

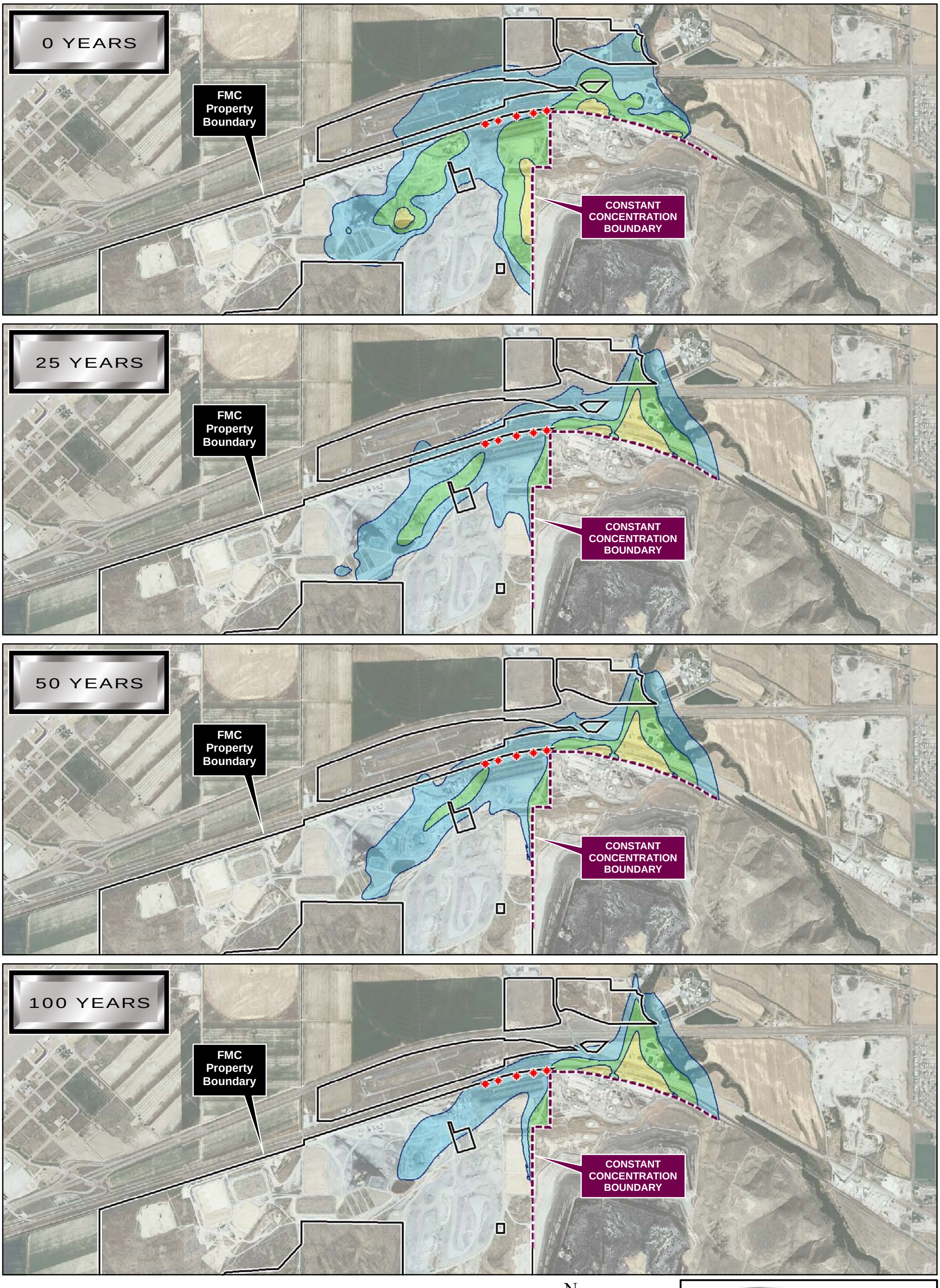
FMC PLANT Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-11

ALTERNATIVE 2 MODEL-PREDICTED ARSENIC PLUME

FILE *Fig 3-12_Alt2_ModelPredicted_Orthophosphate_1109.mxd 12/15/09*



Extracton well

mg/L Milligrams per liter

TOTAL/ORTHOPHOSPHATE LEVELS (mg/L)

- 0.33 - 9.99
- 10 - 99
- 100+

N W E S

0 1200 2400 Feet

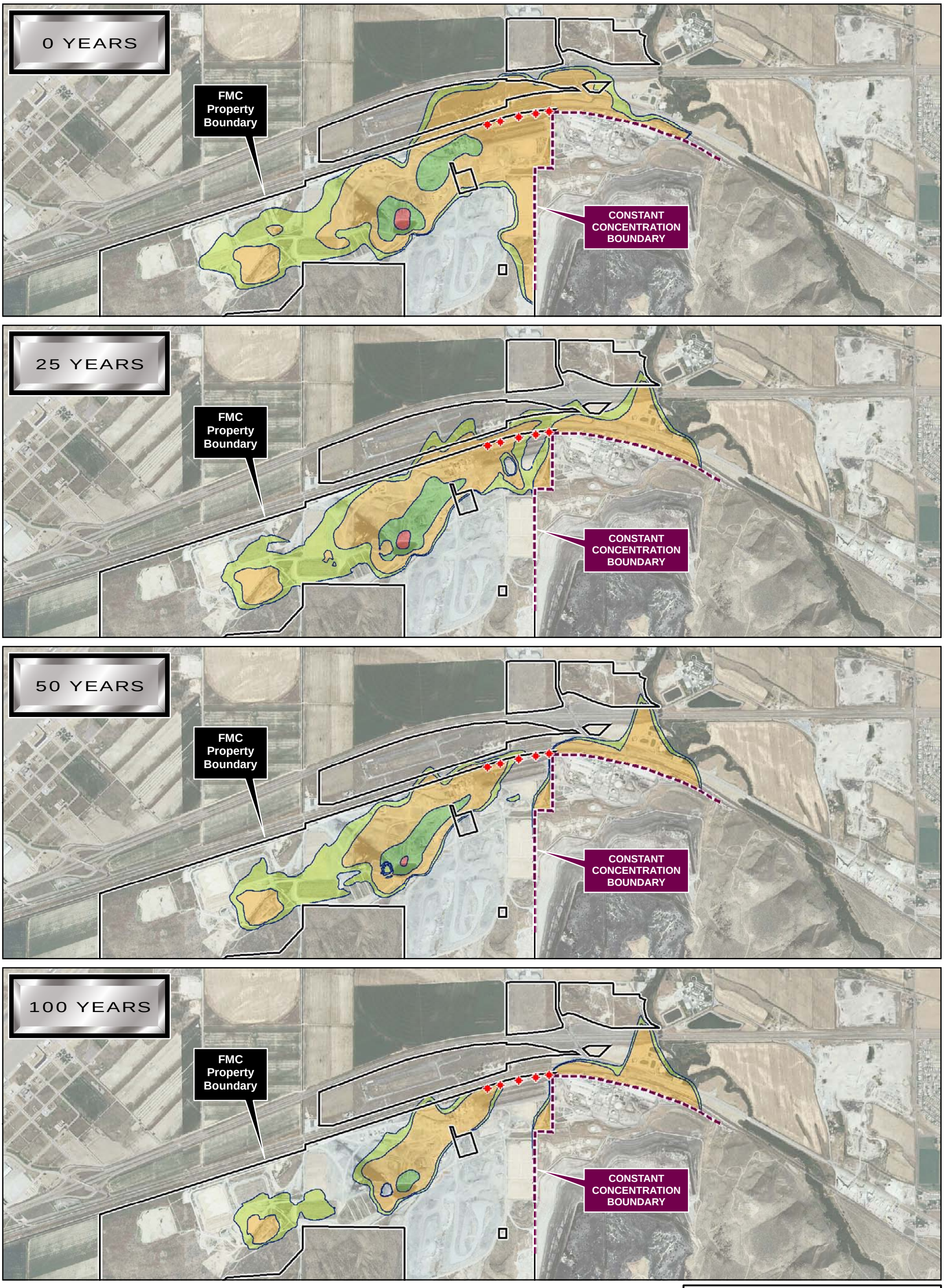
MWH

FMC PLANT Operable Unit

GROUNDWATER MODEL REPORT
FIGURE 3-12

ALTERNATIVE 2
MODEL-PREDICTED
TOTAL/ORTHOPHOSPHATE PLUME

FILE *Fig 3-13_Alt2_ModelPredicted_Potassium_1209.mxd 12/09/09*



POTASSIUM LEVELS
(mg/L)

- 12.7 - 19.9
- 20 - 99.9
- 100 - 499.9
- 500+

Extraction well

mg/L Milligrams per liter

N
W E
S

0 1200 2400
Feet

MWH

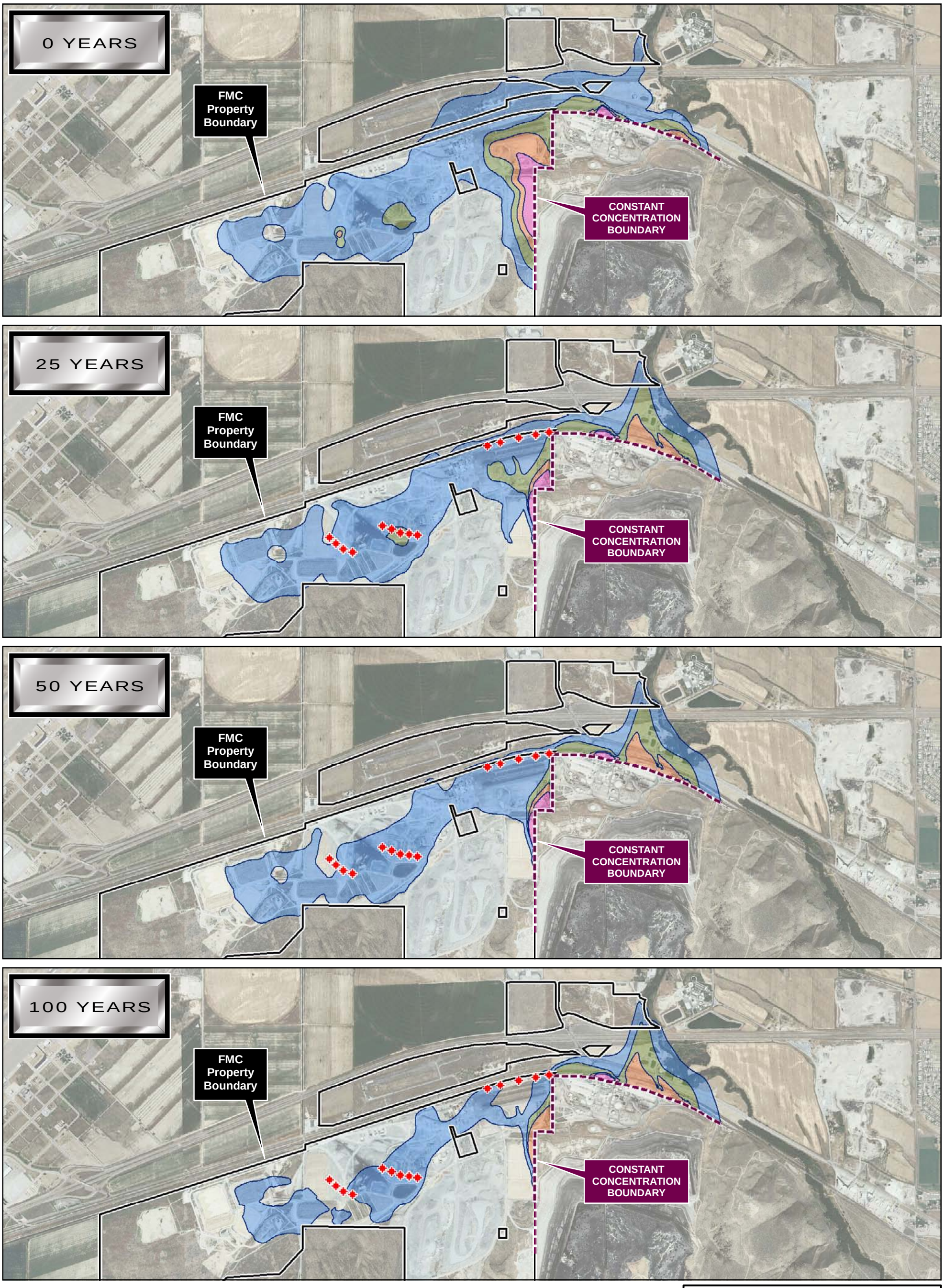
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-13

ALTERNATIVE 2
MODEL-PREDICTED
POTASSIUM PLUME

FILE *Fig 3-14_Alt3_ModelPredicted_Arsenic_0710.mxd 9Jul10*



ARSENIC LEVELS (mg/L)

- 0.010 - 0.09
- 0.20 - 0.29
- 0.10 - 0.19
- 0.30 +

Extraction well

mg/L Milligrams per liter

N W E S

0 1200 2400 Feet

MWH

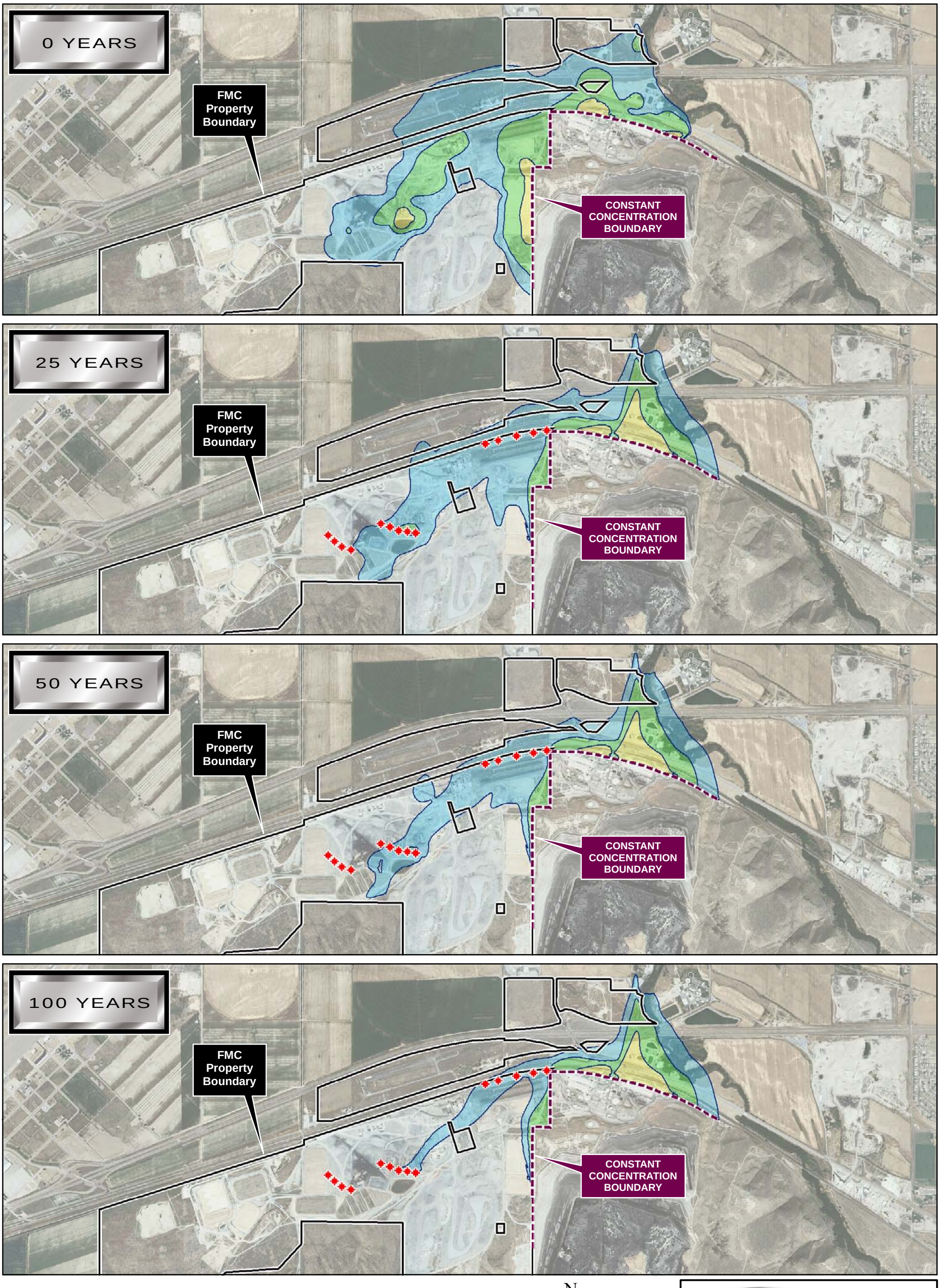
FMC PLANT Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-14

ALTERNATIVE 3 MODEL-PREDICTED ARSENIC PLUME

FILE *Fig 3-15_Alt3_ModelPredicted_Orthophosphate_1209.mxd* *12/16/09*



Extracton well

mg/L Milligrams per liter

TOTAL/ORTHOPHOSPHATE LEVELS (mg/L)

- 0.33 - 9.99
- 10 - 99
- 100+

N W E S

0 1200 2400
Feet

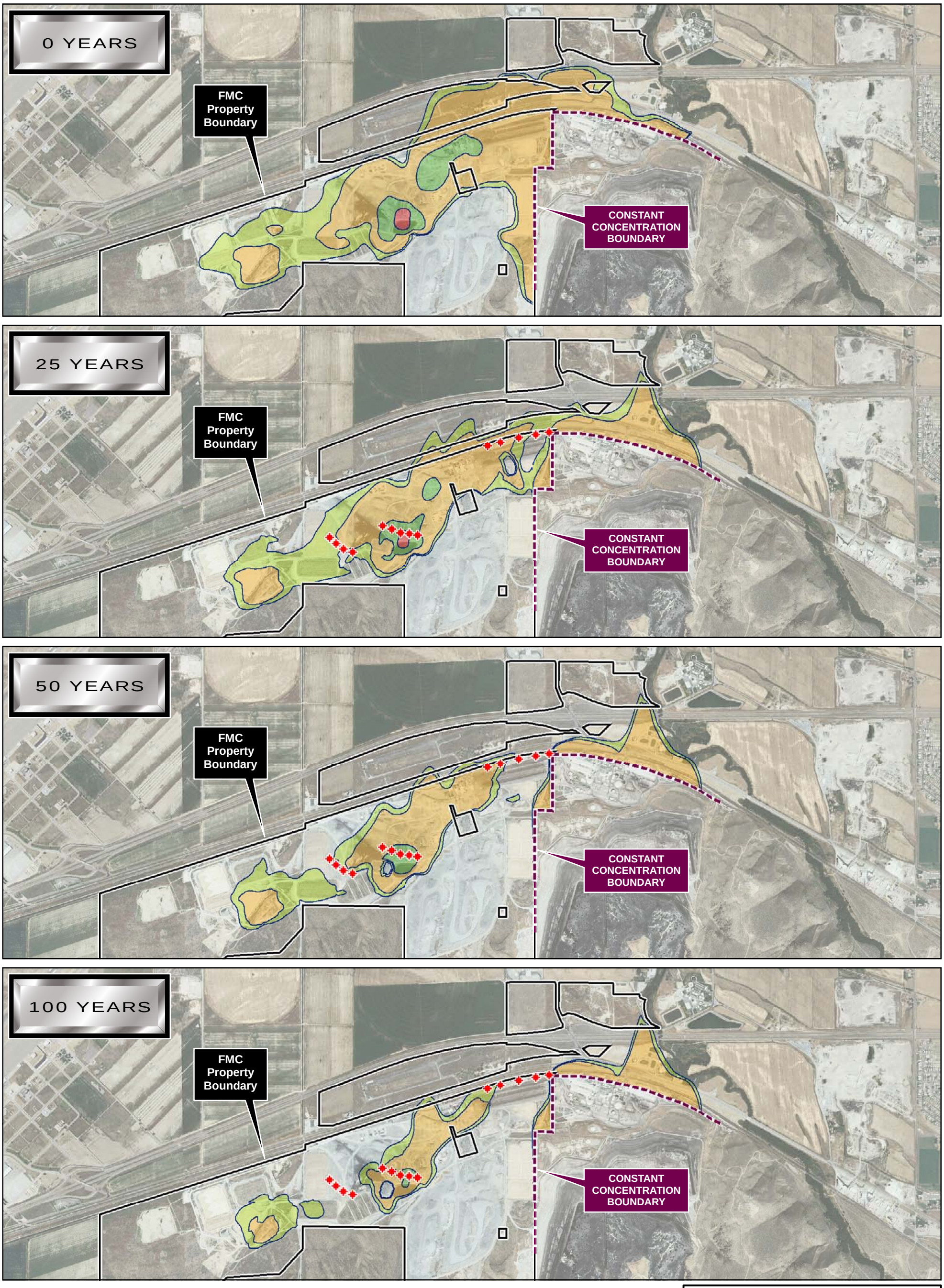
MWH

FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT
FIGURE 3-15

ALTERNATIVE 3
MODEL-PREDICTED
TOTAL/ORTHOPHOSPHATE PLUME

FILE *Fig 3-16_Alt3_ModelPredicted_Potassium_1209.mxd 12/16/09*



POTASSIUM LEVELS
(mg/L)

- 12.7 - 19.9
- 20 - 99.9
- 100 - 499.9
- 500+

Extraction well

mg/L Milligrams per liter

N
W E
S

0 1200 2400
Feet

MWH

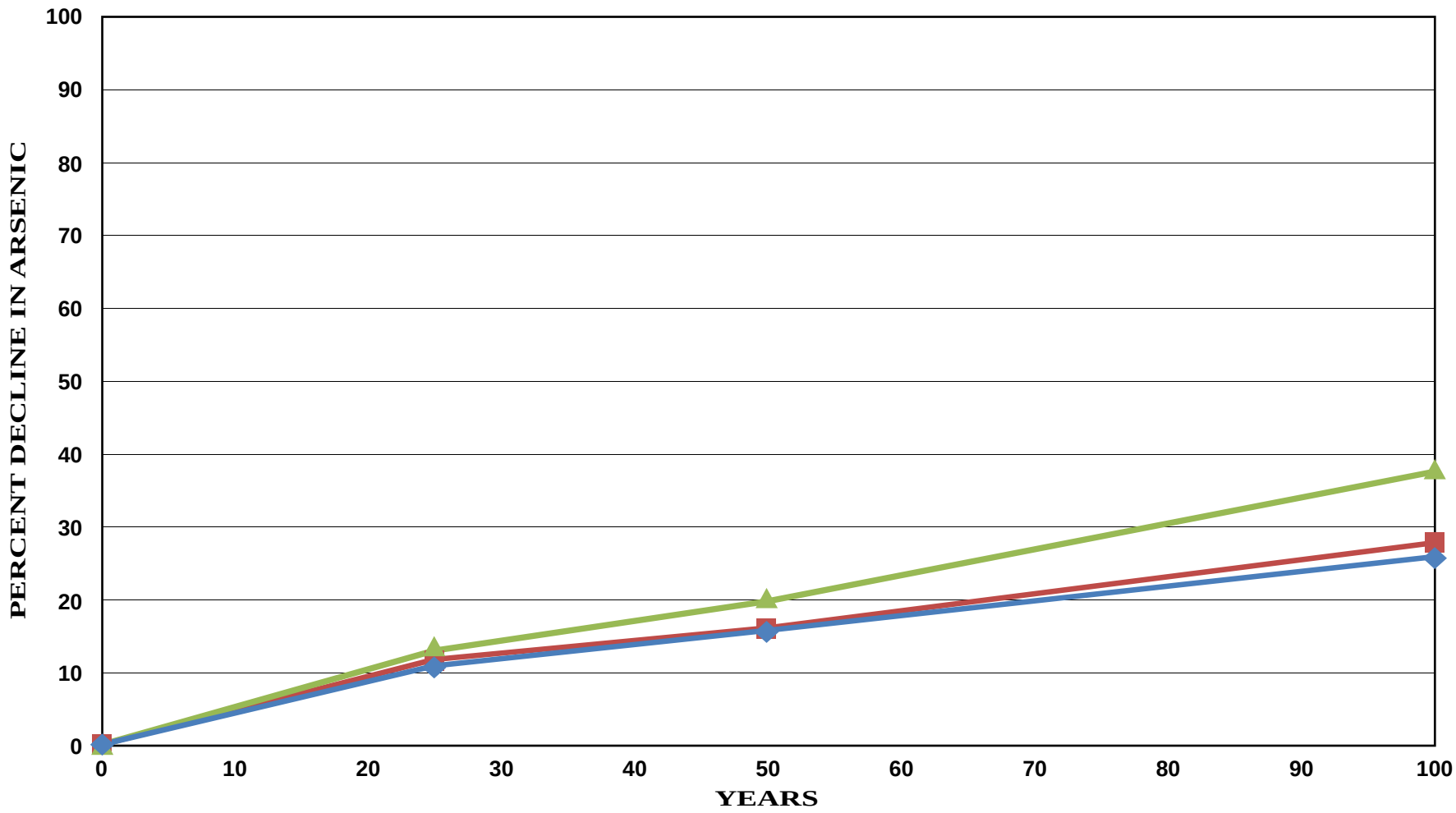
FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-16

ALTERNATIVE 3
MODEL-PREDICTED
POTASSIUM PLUME

FILE *Fig 3-17_Decline in Arsenic Plume Areal Extent through Time_0210.ai 2/17/09*



Alternative 1
Alternative 2
Alternative 3

FMC PLANT
Operable Unit

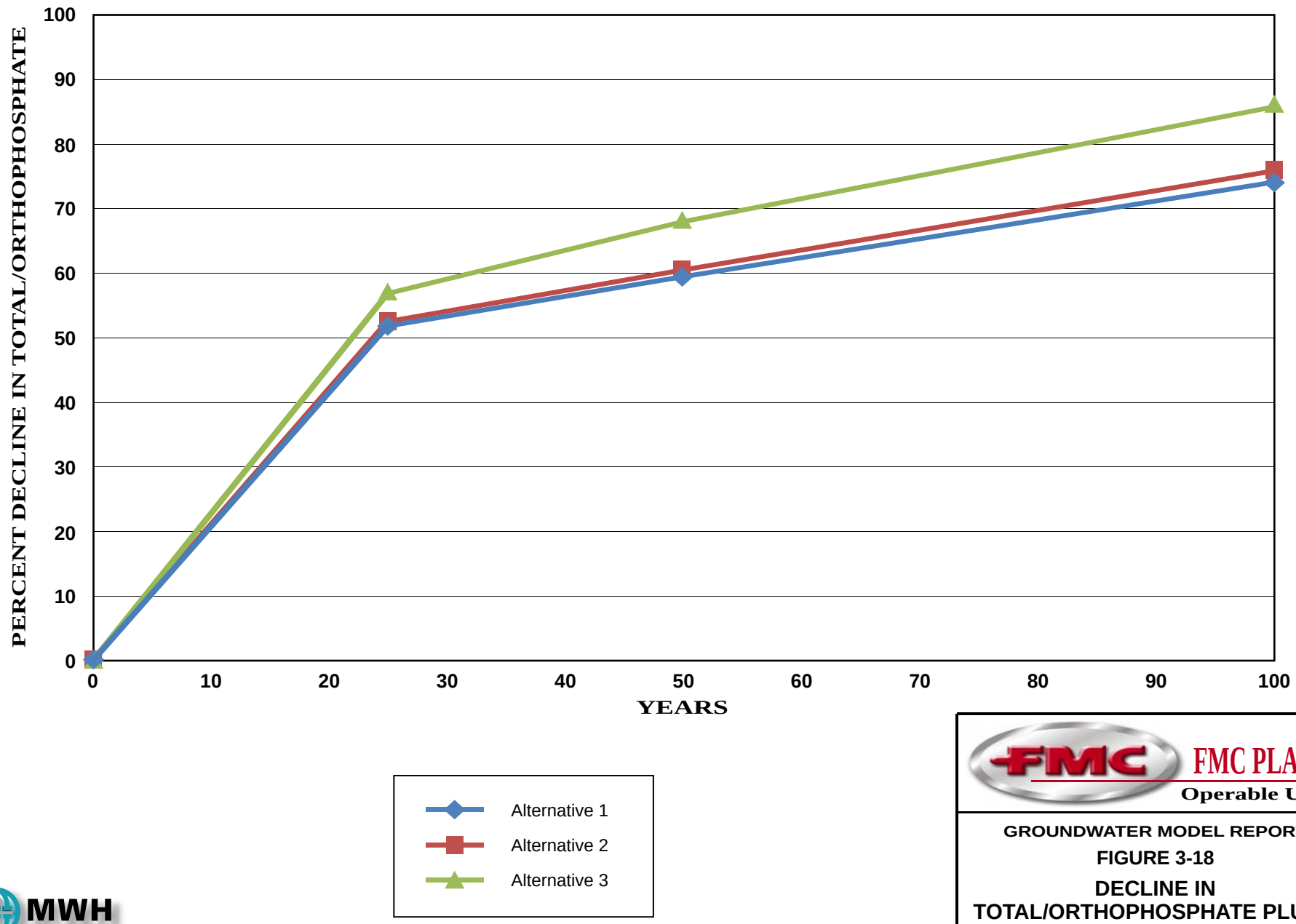
GROUNDWATER MODEL REPORT

FIGURE 3-17

DECLINE IN ARSENIC PLUME AREAL EXTENT THROUGH TIME

MWH

FILE *Fig 3-18_Decline in Total_Orthophosphate Plume Areal Extent through Time_0210.ai 2/17/10*



FMC PLANT
Operable Unit

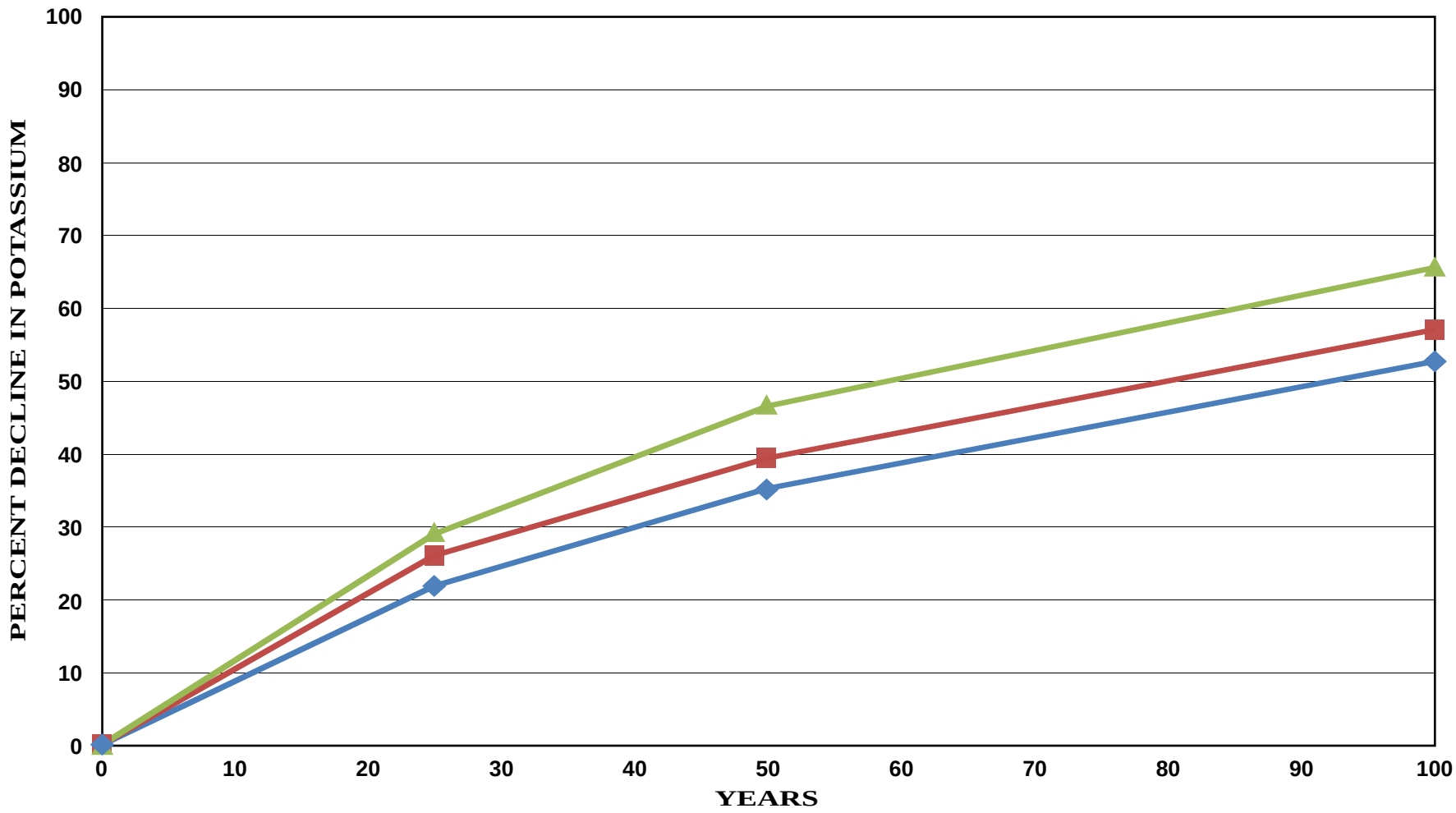
GROUNDWATER MODEL REPORT

FIGURE 3-18

DECLINE IN TOTAL/ORTHOPHOSPHATE PLUME AREAL EXTENT THROUGH TIME

MWH

FILE *Fig 3-19_Decline in Potassium Plume Areal Extent through Time_0210.ai 2/17/10*



Alternative 1
Alternative 2
Alternative 3

FMC PLANT
Operable Unit

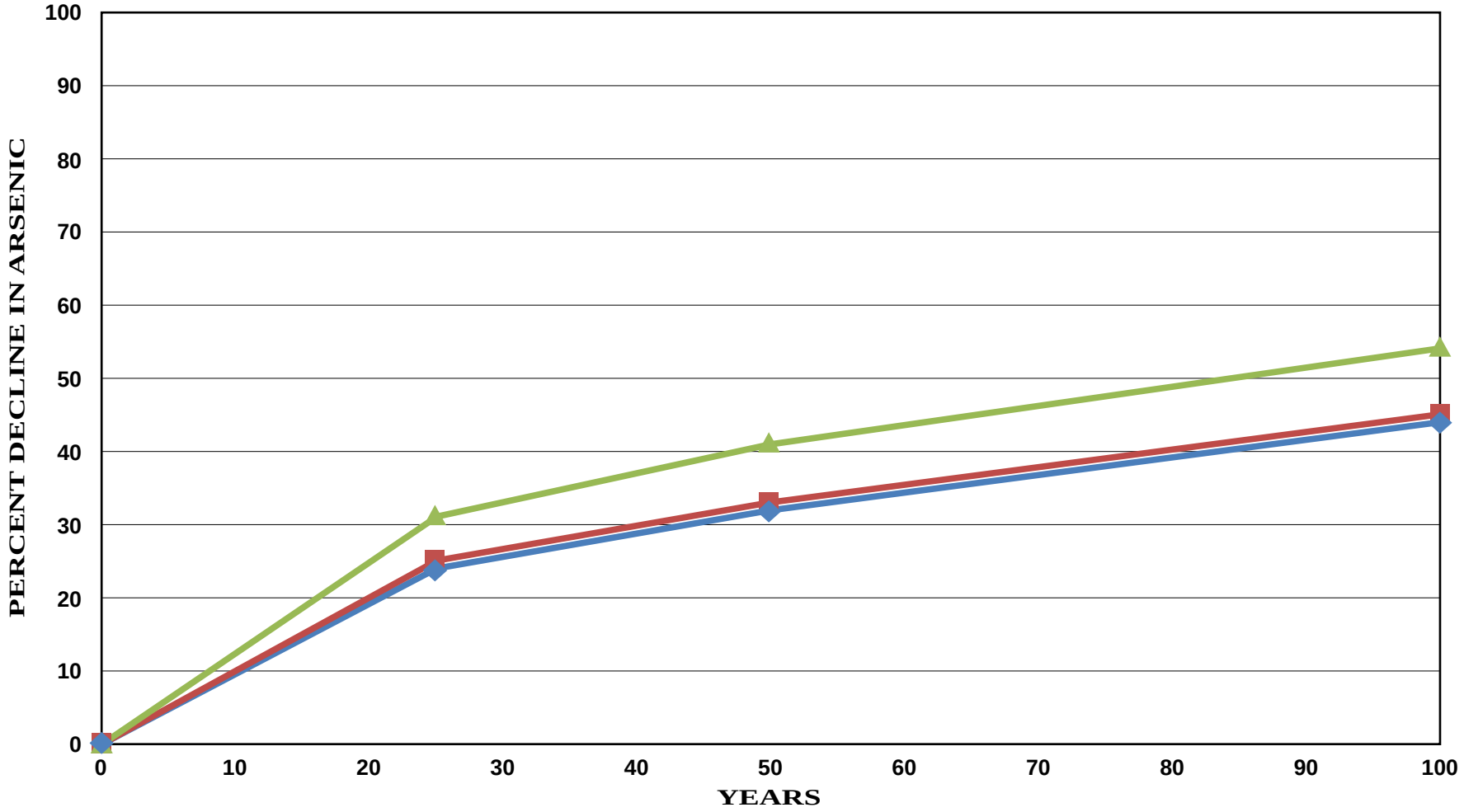
GROUNDWATER MODEL REPORT

FIGURE 3-19

DECLINE IN POTASSIUM PLUME AREAL EXTENT THROUGH TIME

MWH

FILE *Fig 3-20_Decline in Arsenic Mass Over Time_0710.ai 9Jul10*



Alternative 1
Alternative 2
Alternative 3

FMC PLANT
Operable Unit

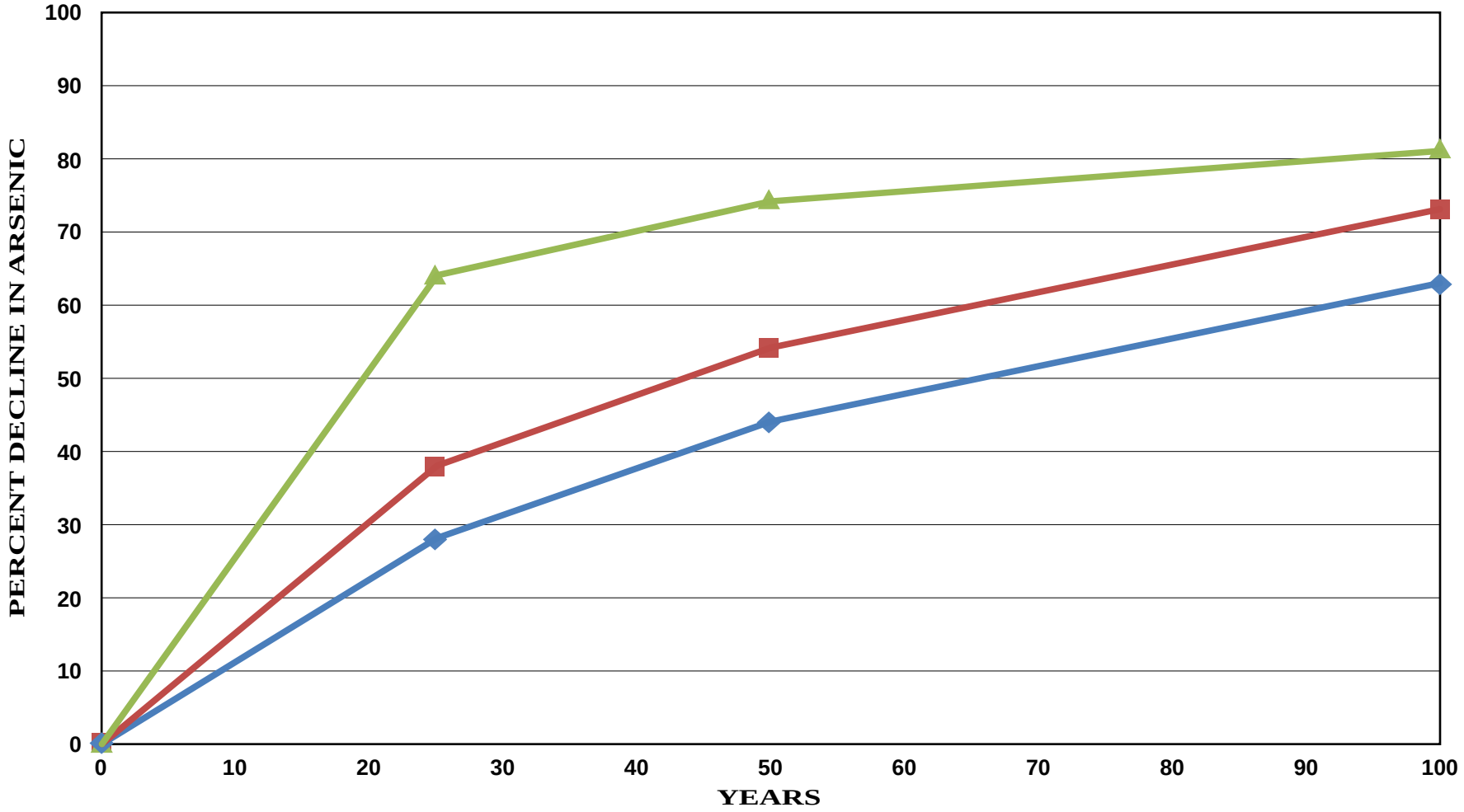
GROUNDWATER MODEL REPORT

FIGURE 3-20

DECLINE IN ARSENIC MASS OVER TIME

MWH

FILE *Fig 3-21_Decline in Total_Ortho-P Mass Over Time_0710.ai 9Jul10*



Alternative 1
Alternative 2
Alternative 3

FMC PLANT
Operable Unit

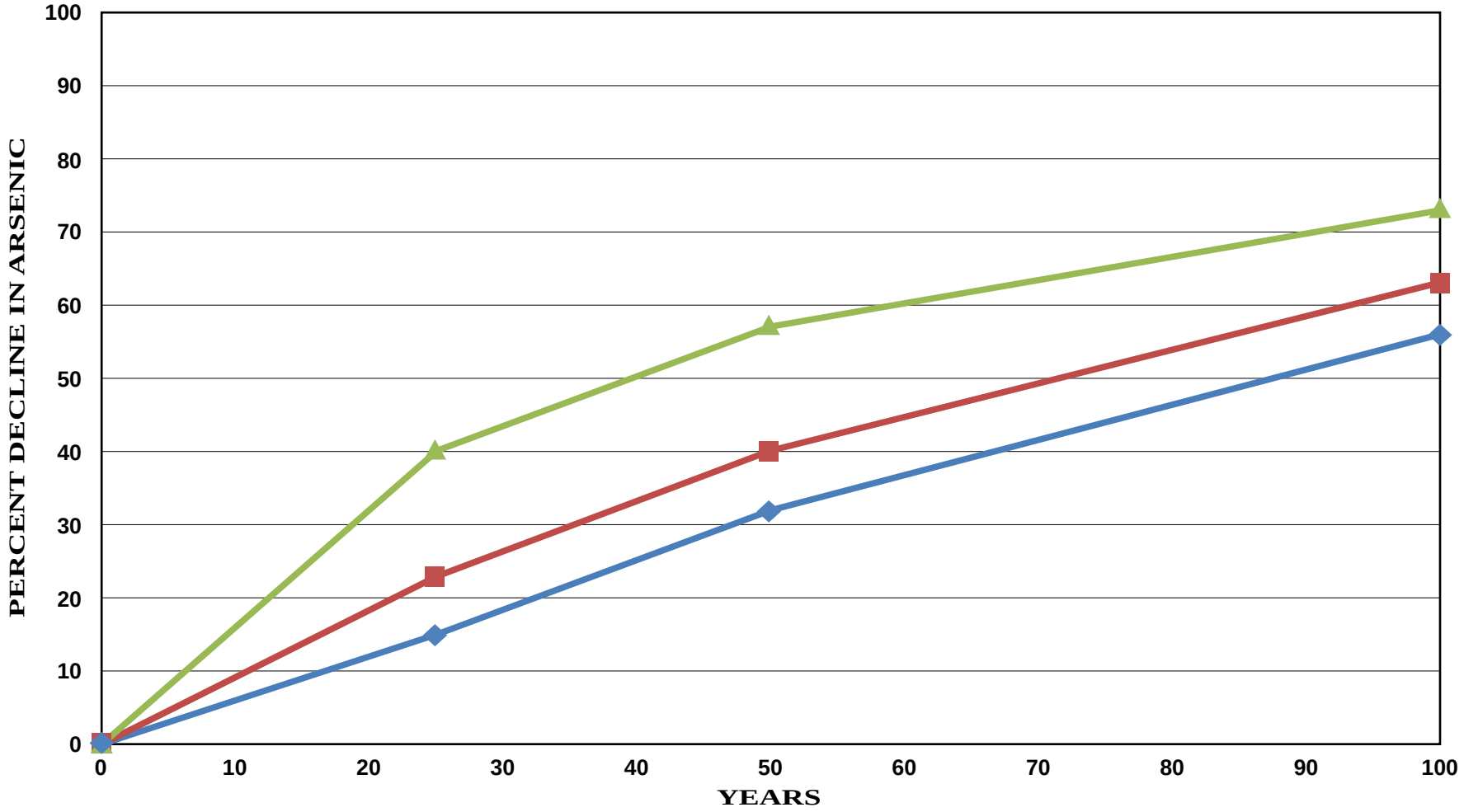
GROUNDWATER MODEL REPORT

FIGURE 3-21

DECLINE IN TOTAL/ORTHO-P MASS OVER TIME

MWH

FILE *Fig 3-22_Decline in Potassium Mass Over Time_0710.ai 9Jul10*



Alternative 1
Alternative 2
Alternative 3

MWH

FMC PLANT
Operable Unit

GROUNDWATER MODEL REPORT

FIGURE 3-22

DECLINE IN POTASSIUM MASS OVER TIME

4.0 CONCLUSIONS

The primary purpose of the groundwater flow and contaminant transport model for the FMC Plant Site was to compare the fate of groundwater contaminants under the proposed SFS groundwater remedial alternatives. The codes MODFLOW, MODPATH, and MT3DMS were used in this modeling effort along with the Department of Defense Groundwater Modeling System (GMS) pre- and post-processor. Over the course of the FMC groundwater model project, FMC convened five meetings with EPA, the Idaho Department of Environmental Quality (DEQ), and the Shoshone-Bannock Tribes (SBT) to engage the agencies in the planning, development, and preliminary results of this modeling effort.

The three-dimensional groundwater flow model was developed and refined during calibration to provide the underlying flow regime for contaminant fate and transport simulations. The calibrated steady-state groundwater flow model developed for the site adequately represents flow conditions at the FMC Plant Site. Based on the calibration statistics, changes in flow model parameter values performed in the sensitivity analysis generally worsened the calibration, or left it unchanged from the calibrated base case.

The contaminant transport model for the site related groundwater constituents arsenic, total phosphorus / orthophosphate, and potassium was developed and refined during calibration (plume matching) to improve estimates of transport parameters. Plume matching results indicate that the parameters selected for both the groundwater flow and contaminant transport models were reasonable and provided an acceptable match between observed and predicted plume configurations. Adjustments to retardation factors and dispersivity were necessary to achieve a reasonable match to the observed contaminant distributions. Overall, the calibrated transport model was most sensitive to changes in sorption coefficients and relatively insensitive to changes in dispersivity and porosity.

Four remedial alternatives are being evaluated in the detailed analysis of alternatives in the SFS report. Because Alternative 0 (No action) does not meet any of the groundwater

RAOs identified in the SFS Report, only Alternatives 1, 2 and 3 were simulated using the calibrated groundwater flow and transport model. The simulated alternatives are:

- **Alternative 1** Source controls, institutional controls and long-term monitoring (LTM);

- **Alternative 2** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, and A) discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation / evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

- **Alternative 3** Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, groundwater extraction at specific source areas, and A) on-site treatment and discharge to the City of Pocatello POTW or B) on-site treatment and discharge to an on-site percolation/evaporation basin(s) located in the western undeveloped portion of the FMC Plant Site.

The modeled groundwater remedial alternatives 2 and 3 extraction well configurations and pumping rates were developed and refined to meet appropriate capture and well drawdown criteria prior to performing the simulations.

Simulation of Alternative 1 indicated that the areal extent of arsenic in groundwater (as defined by the 0.01 mg/l contour) would be reduced by 26 percent and the plume mass would be reduced by 44 percent within the FMC Plant Site over 100 years. The areal extents of total phosphorus/orthophosphate and potassium (above background levels) would be reduced by 62 and 51 percent, respectively, and the contaminant mass would be reduced by 63 and 56 percent, respectively, over 100 years under Alternative 1. RAOs were not met within 100 years under this alternative.

Simulation of Alternative 2 indicated that the areal extent of arsenic in groundwater (as defined by the 0.01 mg/l contour) would be reduced by 28 percent and the plume mass

would be reduced by 45 percent within the FMC Plant Site over 100 years. The areal extents of total phosphorus/orthophosphate and potassium (as defined by their respective background levels) would be reduced by 64 and 56 percent, respectively, and the contaminant mass would be reduced by 73 and 63 percent, respectively, over 100 years under Alternative 2. RAOs were not met within 100 years under this alternative.

Simulation of Alternative 3 indicated that the areal extent of arsenic in groundwater (as defined by the 0.01 mg/l) would be reduced by 37 percent and the plume mass would be reduced by 54 percent within the FMC Plant Site over 100 years. The areal extents of total phosphorus/orthophosphate and potassium (as defined by their respective background levels) would be reduced by 79 and 65 percent and the contaminant mass would be reduced by 81 and 73 percent, respectively, over 100 years under Alternative 3. RAOs were not met within 100 years under this alternative.

Sensitivity analysis indicated that the transport model was most sensitive to uncertainty in sorption coefficients. Therefore, additional predictive simulations were run in which these coefficients were halved and doubled. Even with these lower sorption coefficients, RAOs were not met for any of the groundwater constituents within 100 years.

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APPENDIX A
GROUNDWATER MODEL MEETING MINUTES
(Provided Electronically Only)

Agenda
FMC Plant OU – SRI/SFS Meeting
Booz Allen Hamilton – 720 Olive Way - Seattle, WA
May 20-21, 2009

Wednesday, May 20

8:00 AM Overview FMC's interim deliverable package of Assembled Soil Remedial Alternatives
- Soil Technology Screening Table Update from February 25-26 meeting
- Core Remediation Elements Common to all Alternatives
- Cap Technology Review
- Rail car tech memo

Detailed discussion/review of Assembled Soil Remedial Alternatives

Noon Lunch

1:00 PM Resume discussion of Assembled Soil Alternatives & Discussion of Initial Screening table

Summarize action items/path forward for Assemble Soil Remedial Alternatives

2:30 PM Review discussions / path forward agreed upon at February 25-26 meeting regarding
- Field Modification # 13 work – Southern & Western Undeveloped Areas
- Field Modification # 14 work – FMC Northern Properties & Background locations

Review analytical results received since that meeting

Review protocols for data analyses and preliminary results

4:00 PM Adjourn

Thursday, May 21

8:00 AM Review draft updates to Groundwater Technology Screening Table

Review Conceptual Approaches to Assembly of Groundwater Remedial Alternatives

11:00 AM SRI/SFS Overall Project Timeline Review and Update

Noon Adjourn

FMC Plant OU – Groundwater Discussion
Agency-FMC Meeting May 21, 2009

- Status of Agency Review of FMC's Response to Comments and Revised Groundwater Current Conditions Report
- Revised SFS Groundwater Technology Screening Table (SFS Table 6.2)
- Conceptual SFS Groundwater Remedial Alternatives
- Overview of Groundwater Modeling to Support Development and Comparative Analysis of GW Alternatives

Table 6.2 - PRELIMINARY Groundwater Remedial Technologies Screening
FMC Pocatello Facility

Process Option	Effectiveness	Implementability	Cost	Decision Rational	Retained
No Action					
No Action	Acceptable for constituents that meet ARARs and Remedial Action Objectives (RAOs).	Not applicable	None	Always retained in FS as base case and may be used in areas that pose no risk.	Yes
Institutional Controls					
Access Restrictions					
Land and Groundwater Use Restrictions	Effective at prohibiting designated types of land (e.g., residential) or groundwater (e.g., human consumption) use through legal mechanisms such as deed restrictions, covenants and environmental easements that have continuing effect in perpetuity or until occurrence of defined terminating event.	Straightforward	Low capital, Low O&M	Deed restrictions preventing residential land use are already in place. Groundwater use restrictions were selected in the 1998 ROD and are still an appropriate component of the groundwater remedy.	Yes
Monitoring					
Ground Water Monitoring	Effective for monitoring any trends in concentrations, extent and migration of site-impacted groundwater.	Straightforward. May require installation of additional monitoring wells to optimize well network.	Moderate capital, Low O&M	Groundwater monitoring is currently on-going at the site, was selected in the 1998 ROD and is still an appropriate component of the groundwater remedy.	Yes
Source Controls					
Source Controls	Effective for reducing or eliminating constituent migration to groundwater from identified and potential source areas.	Generally straightforward. Numerous source control actions (e.g., Pond 8S closure, Calciner Pond Remedial Action) have already been completed at the site.	Moderate capital, Moderate O&M	Major source controls actions have already been completed at the site, source controls were identified in the 1998 ROD as a component of the groundwater remedy and remain an appropriate component of the remedy.	Yes
Containment					
Vertical Barriers					
Extraction Wells	Effective for providing capture and hydraulic containment to minimize downgradient migration of site-impacted groundwater.	Straightforward. Would likely require treatment of extracted groundwater prior to use/disposal.	Moderate capital, High O&M	Effective and implementable. Groundwater extraction for hydraulic control was identified in the 1998 ROD as a contingent component of the groundwater remedy and is still appropriate for consideration as a component of the groundwater remedy.	Yes
Injection Wells	Potentially effective for establishing a hydraulic barrier to eliminate down-gradient migration of contaminated groundwater.	Implementable, but would require identifying a clean source of water. May require installation of up-gradient extraction wells to provide source of clean water.	Moderate capital, High O&M	Potentially effective and implementable. Possibly will be retain for comparison to extraction option.	No
Cut-off (Slurry or Grout) Walls	Potentially effective for establishing a hydraulic barrier to eliminate down-gradient migration of contaminated groundwater.	Difficult to implement given that groundwater is present at depths greater than 80 feet.	High capital, Low O&M	Not likely implementable due to the significant depths (>80 feet) of groundwater at the site. Containment would be more practical using hydraulic method including injection and extraction.	No

Table 6.2 - PRELIMINARY Groundwater Remedial Technologies Screening
FMC Pocatello Facility

Process Option	Effectiveness	Implementability	Cost	Decision Rational	Retained
Removal and Disposal					
Removal					
Pumping	Effective for capturing and decreasing mass of constituents in groundwater.	Readily implementable but would likely require treatment of groundwater prior to discharge or re-use.	Moderate capital, High O&M	Probably will be retained mainly to evaluate extraction in areas of highest groundwater constituent concentrations (e.g., highest mass removal) for comparison to extraction for hydraulic control.	Yes
Disposal					
Recycle-Reuse	Effective for providing a beneficial-use for the extracted groundwater; uses may include irrigation and dust control.	Potentially implementable but would likely require treatment of groundwater prior to discharge or re-use.	Low capital, Low O&M	Probably will be retained as preferred disposal option to promote beneficial water use. May not be able to use all water that is pumped.	Yes
Surface Water	Effective for disposal of treated water.	Potentially implementable but would require treatment of groundwater and a NPDES discharge permit prior to discharge to surface water.	Low capital, Low O&M	Possibly will be retained as a disposal option for large quantities of water. Would required NPDES discharge permit which would require treatment of water prior to discharge.	No
POTW	Effective for disposal of treated water.	Potentially implementable but would likely require pretreatment of groundwater prior to discharge to POTW.	Low capital, Low O&M	Possibly will be retained as a disposal option for large quantities of water. Would required industrial discharge permit which would require treatment of water prior to discharge.	Yes
Reinjection	May not be effective for disposal of large amounts of water due to hydrogeological conditions at the site. Would only be effective if the extracted groundwater was treated prior to reinjection.	Inplementability will depend on the locations at depths of wells. Wells may not be capable off handling all extracted water. Would require treatment below MCLs if reinjected.	Moderate capital, Low O&M	Due to difficulty in predicting capacity of injection wells and necessity for extremely high level of treatment, reinjection is not likely to be retained.	No
Ex-Situ Treatment					
All ex-situ technologies would require the pumping of impacted groundwater from extraction wells prior to treatment. The ex-situ technologies idenitifed and screened below are for treatment of the overall site-impacted groundwater (e.g., arsenic, nutrients, flouride). Technologies that may be effective for treatment of P4 in groundwater that has been detected downgradient from RUs 1 and 2 are discussed under effectiveness and implementability.					
Separation	Effective in conjunction with other treatment technologies to remove suspended (precipitated) solids, which may contain constituents of concern.	Readily implementable May require additional treatment to meet discharge standards.	Moderate capital, Moderate O&M	Possibly retained for use in conjunction with other treatment options but ineffective as a standalone technology.	No
Filtration	Effective in conjunction with other treatment technologies to remove suspended (precipitated) solids, which may contain constituents of concern.	Readily implementable May require additional treatment to meet discharge standards.	Moderate capital, Moderate O&M	Likely to be retained only for possible use in conjunction with other treatment options, ineffective as a standalone treatment technology.	No
Adsorption	Effective in conjunction with other treatment technologies to remove dissolved arsenic down to MCL.	Readily implementable. May require additional treatment to meet discharge standards.	High capital, High O&M	Likely to be retained as an effective treatment technology for removing arsenic down to MCL. May require additional treatment if elemental phosphorus is present.	No

Table 6.2 - PRELIMINARY Groundwater Remedial Technologies Screening
FMC Pocatello Facility

Process Option	Effectiveness	Implementability	Cost	Decision Rational	Retained
Ion Exchange	Not effective for constituents of concern in groundwater.	Readily implementable but requires generation of additional waste streams.	Moderate capital, Moderate O&M	Not likely to be retained due to ineffectiveness for constituents of concern.	No
Reverse Osmosis	Effective for removing dissolved solids down to discharge standards.	Readily implementable but has high electrical requirements and produces additional waste stream that requires	High capital, High O&M	Not likely to be retained due to high capital and O&M costs compared to other technologies. Exceeds treatment requirements.	No
Chemical Precipitation	Effective for removing arsenic down to the MCL.	Straightforward for low to medium flows.	Moderate capital, High O&M	Probably will be retained as a treatment technology for removal of metals and/or phosphate if discharge is required.	Yes
Oxidation/Reduction	Potentially effective for converting elemental phosphorus to phosphate but would require additional treatment to remove phosphate if discharge is necessary. Limited applicability to other chemicals of concern (e.g., arsenic and selenium).	Implementable for dissolved phase elemental phosphorus.	Moderate capital, High O&M	Probably will be retained as a treatment step for P4-containing groundwater.	Yes
Hydrolysis	Potentially effective for converting elemental phosphorus to phosphorus compounds but would require additional treatment to remove phosphate if discharge is necessary. Limited applicability to other chemicals of concern (e.g., arsenic and selenium).	Implementable for dissolved phase elemental phosphorus.	Moderate capital, High O&M	Probably will be retained as a treatment step for P4-containing groundwater.	No
Evaporation	Effective for concentrating dissolved metals and inorganics in conjunction with other processes	Not implementable for large flows unless pond is constructed for storage of water.	High capital, High O&M	Probably will not be retained due to high capital and O&M costs compared to other technologies.	No
In-Situ Treatment					
The in-situ technologies idenitifed and screened below are for treatment of the overall site-impacted groundwater (e.g., arsenic, nutrients, flouride). Technologies that may be effective for treatment of P4 in groundwater that has been detected downgradient from RUs 1 and 2 are discussed under effectiveness and implementability.					
Chemical Injection (Oxidation/Hydrolysis)	Not effective for treatment of inorganic COCs (e.g., metals, nutrients). Potentially effective for oxidizing or hydrolyzing P4-containing groundwater, but effectiveness will likely be reduced due to inability to deliver uniform spatial coverage. May also increase mobility of inorganic species (e.g., metals).	May be difficult to implement due to low hydraulic conductivity of silts in the capillary fringe.	Moderate capital, High O&M	Chemical oxidation may be effective at accelerating oxididation of dissolved P4 in groundwater. However, It may increase mobility of some other inorganic species (e.g., metals). In-situ hydrolysis of P4-containing groundwater would have similar challenges to chemical/physical oxidation (effective delivery and coverage) but would also have the negative effect of adding salts (TDS) to the groundwater system.	No
Mechanical Aeration	Not effective for treatment of inorganic COCs (e.g., metals, nutrients). Potentially effective for oxidizing P4-containing groundwater. Effectiveness may be reduced due to inability to deliver uniform spatial coverage.	May be difficult to implement due to depth to groundwater and low hydraulic conductivity of silts at the capillary fringe.	Moderate capital, High O&M	Due to limitations with respect to spatial coverage, mechanical aeration is not likely a viable in-situ technology.	No

Table 6.2 - PRELIMINARY Groundwater Remedial Technologies Screening
FMC Pocatello Facility

Process Option	Effectiveness	Implementability	Cost	Decision Rational	Retained
Reactive Barrier	Permeable reactive barriers (PRB) are potentially effective for treatment of inorganic COCs (metals and nutrients). Effectiveness may be limited due to existing groundwater conditions near source areas that are already near typical target conditions for reactive barriers (e.g. reduced redox and anion saturation to promote mineral precipitation). There are also uncertainties regarding long-tem PRB performance / functional life.	Continuous trench, funnel and gate and wall and curtain construction methods, most commonly using zero valent iron (ZVI), not implementable due to depth to groundwater / 'base' of shallow groundwater zone. Based on available literature, PRBs are typically 5 to 15 feet deep and the deepest PRB that has been installed is 46 feet bgs.	High capital, Moderate to High O&M	PRBs have been used with some success to treat groundwater contaminated with metals and nutrients. However, due to the depth to groundwater / base of shallow groundwater zone, PRBs are not a viable technology.	No
Chemical Injection (Reductive Reaction Zone)	Chemical injection reaction zones are potentially effective for treatment of inorganic COCs (metals and nutrients).Effectiveness may be limited due to existing groundwater conditions near source areas that are already near typical target conditions for reactive barriers (e.g. reduced redox and anion saturation to promote mineral precipitation). Effectiveness may also be limited due to inability to deliver uniform spatial coverage. There are also uncertainties regarding long-tem PRB performance / functional life.	Chemical injection (e.g., insitu redox manipulation) has been implemented at full scale at Hanford Site 100 D area using sodium dithionite with a potassium carbonate/potassium bicarbonate buffer (pH 11); however, after initial installation additional modifications are needed to meet performance objectives (proposing to inject polyactate and micron-sized ZVI and increase pump and treat flow rate) . Chemical injection may be difficult to implement due to low hydraulic conductivity of silts at the capillary fringe and upper saturated zone.	Moderate to High capital, High O&M	Chemical injection reation zones have been used with some success to treat groundwater contaminated with metals and nutrients. However, 1) existing groundwater chemistry conditions, 2) uncertainties associated with ability to achieve uniform mixing throughout vertical profile of shallow groundwater zone 3) performance uncertainties, and 4) associated moderate to high capital and high O&M costs, a chemical injection reductive reaction zone is not likely a viable technology.	No
Thermal Desorption	In-Situ thermal desorption (ISTD) has been effective at treating soil contaminated with VOCs and SVOCs, but is not effective for treatment of inorganic COCs (e.g., metals, nutrients). ISTD has not been tested on soils/groundwater contaminated with P4 and representatives of TerraTherm indicated that significant testing would be required to determine whether this technology could be utilized on P4 . They suggested that at first review this technology is not suitable for the site conditions.	Has been implemented at full-scale to treat soil contaminated with VOCs and SVOCs. However, as never been implemented at a site with P4 or demonstrated to be effective at treating P4. ISTD would require the continuous addition of oxygen into the treatment zone to promote oxidation. Due to the depth estimated of the treatment zone (80-90 feet bgs), the background oxygen levels would be low and would be quickly consumed during the process. To ensure continued oxidation, air would need to be introduced uniformly throughout the target treatment zone. This would be very difficult, if not impossible, given the low-permeability fine-grained sediments (primarily silts) in the target zone. In addition, removal of the P4 reaction products would be difficult due to the fine-grained nature of the treatment zone.	High capital, High O&M	ISTD has been used to treat soils contaminated with organics but is not effective for metals and nutrients. However, 1) due to the difficulties associated with the depth to groundwater and geologic conditions at this site, 2) unproven effectivenss for treating soils/groundwater containing P4, and 3) associated high capital and O&M costs, this technology has limited applicability in the capillary fringe / groundwater containing P4 at the site.	No

Conceptual Groundwater Remedial Alternatives

Alternative 1

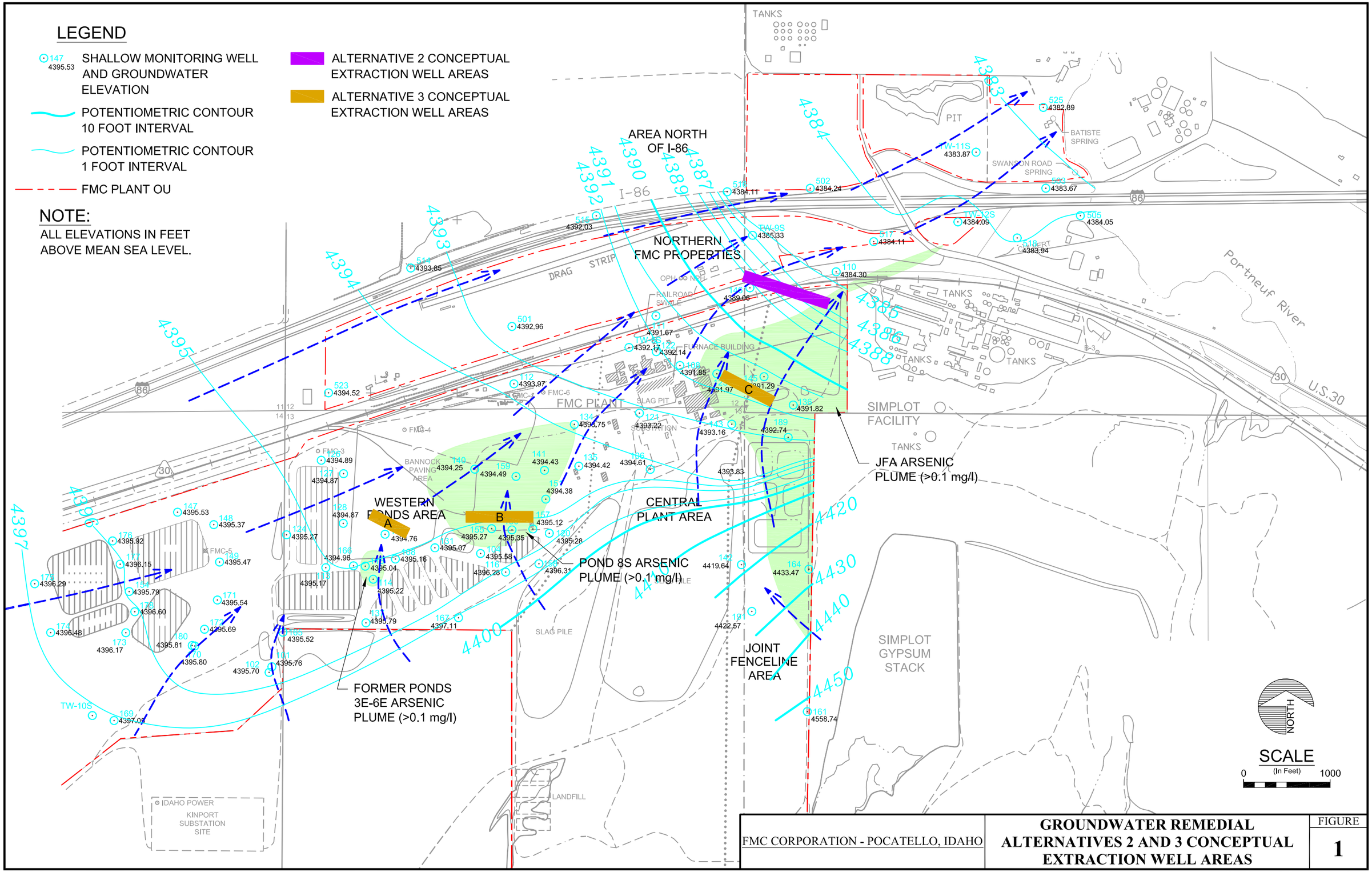
- Source Controls (i.e., Soil Remedial Actions)
- Institutional Controls (Prevent use/ingestion of site-impacted groundwater)
- Long-term groundwater monitoring

Alternative 2

- Alternative 1 components
- Groundwater extraction for hydraulic containment at plant boundary
- Treatment and/or use of extracted groundwater

Alternative 3

- Alternative 1 components
- Groundwater extraction at identified source areas
- Treatment and/or use of extracted groundwater



FMC CORPORATION - POCATELLO, IDAHO

GROUNDWATER REMEDIAL ALTERNATIVES 2 AND 3 CONCEPTUAL EXTRACTION WELL AREAS

FIGURE 1

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Hydrometrics, Inc.
Consulting Scientists and Engineers

Groundwater Model to Support SFS

- Development of new 3-D groundwater flow and contaminant transport model
  - Model domain will encompass FMC and Simplot areas (domain similar to EMF RI GW model)

- Groundwater flow model using MODFLOW with pre-/post-processor GMS
  - Source/sink values based on 2008 (e.g., Simplot production pumping)
  - Calibration target will be average 2008 water levels

- Transport model using MT3DMS with pre-/post-processor GMS and coupled with MODFLOW
  - Base year 2008 (observed concentrations at FMC and Simplot)
  - Constituents simulated: arsenic, potassium and total phosphorus / orthophosphate
  - Transport calibration to match observed constituent distribution

Groundwater Model to Support SFS (Cont.)

- Predictive Simulations
  - Groundwater Alternatives 1, 2, and 3
  - Iterative refinement of Alternatives 2 and 3 (i.e., location and number of extraction wells and extraction rate)
  - Simplot conditions will be “held” at 2008

- Milestones for review with Agency
  - Calibrated groundwater flow model and discuss plans for transport model – week of June 29 (30th or July 1st)
  - Calibrated groundwater flow and transport model and review preliminary predictive simulations – week of August 3rd (5th, 6th or 7th)

Rob Hartman

From: Rob Hartman
Sent: Friday, June 26, 2009 10:43 AM
To: Kira Lynch; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; Fisher.Carla@epa.gov
Cc: Barbara Ritchie; Marc Bowman; Doug Oliver; Zachary Brown
Subject: Revised Agenda for FMC Groundwater Flow Model Meeting, July 1, IDEQ office, Pocatello, ID

Per communication from Bernie Zavala, Randall Ross and Milovan Beljin from EPA ORD/Ada will not be able to attend the FMC groundwater flow model meeting in person, but will participate via conference telephone. I have revised the agenda to consolidate the meeting topics and moved the site tour to the end of the day.

Bernie: Please forward this message to Randall and Milovan with the dial-in information as follows:

Conference Line: 888-403-8897
Participant Code: 2152996700

Finally, we will circulate the presentation materials prior to the meeting for those participating by telephone. Bernie, please forward email addresses for Randall and Milovan so that we can get them on the route list for those materials.

Revised Agenda for Agency-FMC Meeting on FMC Groundwater Flow Model
July 1, 2009, DEQ Office, Pocatello, ID
(All Times = Mountain Daylight Time)

8:00 - 9:45	Introductions Summary of site geology and hydrogeology and surface water Summary of nature and extent and transport of site-impacted groundwater
10:00 – 12:00	Groundwater model objective Flow model construction (boundaries/grid, layers, boundary conditions, sources / sinks) Flow model calibration – targets and results Transport model planning and input discussion
12:00 - 1:30	Lunch break
1:30 – 2:30	Review conceptual groundwater remedial alternatives Preliminary discussion of predictive simulations Meeting recap and wrap-up
3:00 – 4:00	Site tour

Agenda for Agency-FMC Meeting on FMC Groundwater Flow Model
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	Preliminary discussion of predictive simulations
	Meeting recap and wrap-up
3:00 – 4:00	Site tour

FMC
Supplemental Feasibility Study
Groundwater Modeling Update

July 1, 2009
Pocatello, Idaho

MWH

BUILDING A BETTER WORLD

Agenda

8:00 - 9:45	Introductions Summary of site geology and hydrogeology and surface water Summary of nature and extent and transport of site-impacted groundwater
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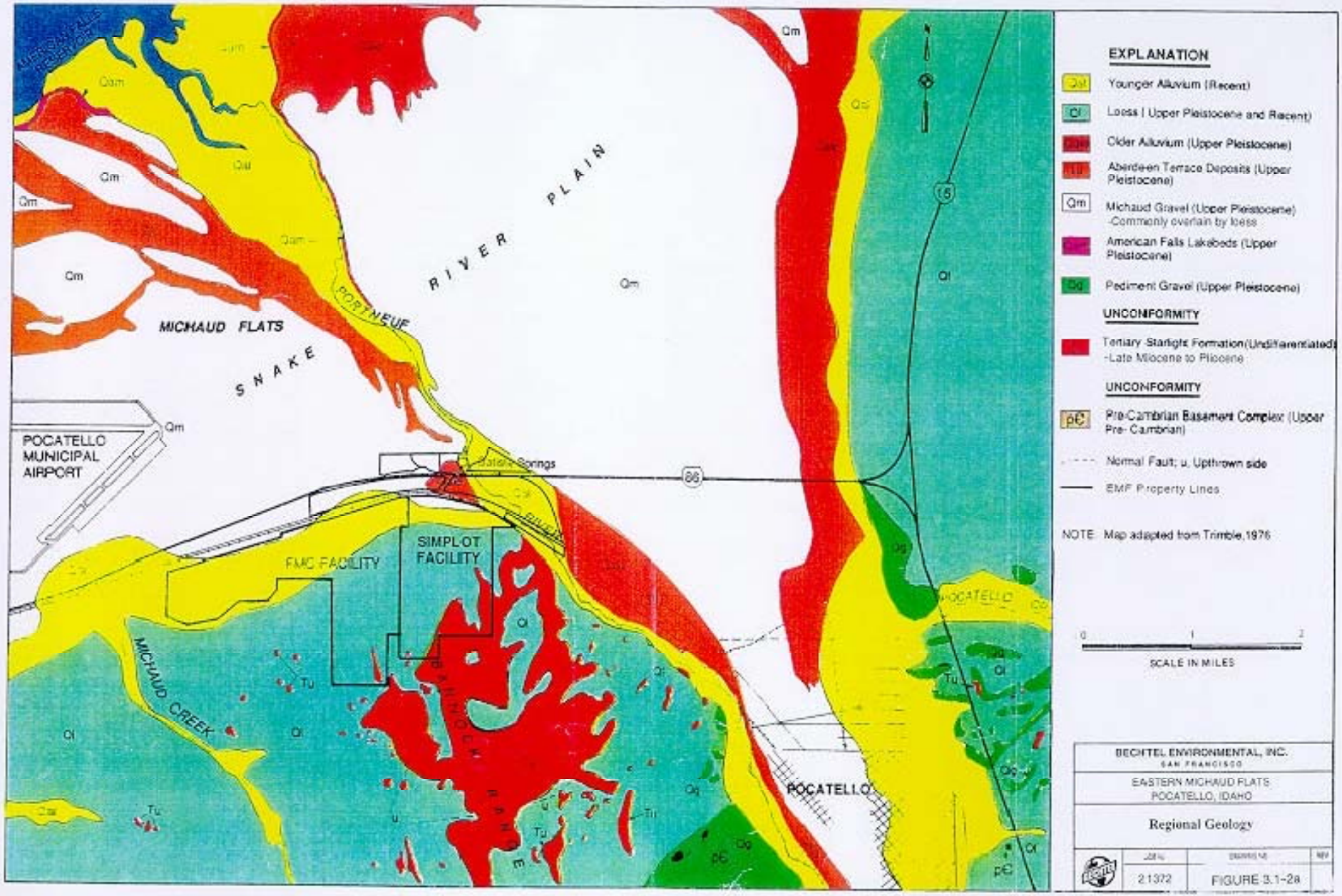
3:00 – 4:00	Site tour

Geology

- Transition from Bannock Range to Snake River Plain.
- Stratigraphy can generally be described as discontinuous layers of unconsolidated sediments deposited on an erosional surface incised in volcanic bedrock.
- Fine-grained silts, clays, and sands form a discontinuous, semi-confining unit (American Falls Lake Bed deposits).


EXPLANATION
Qal Younger Alluvium (Recent)
Ql Loess (Upper Pleistocene and Recent)
Qoa Older Alluvium (Upper Pleistocene)
Qa Aberdeen Terrace Deposits (Upper Pleistocene)
Qm Michaud Gravel (Upper Pleistocene) -Commonly overlain by loess
Qf American Falls Lakebeds (Upper Pleistocene)
Qg Pediment Gravel (Upper Pleistocene)
UNCONFORMITY
Tu Tertiary Starlight Formation (Undifferentiated) -Late Miocene to Pliocene
UNCONFORMITY
pЄ Pre-Cambrian Basement Complex (Upper Pre- Cambrian)
Normal Fault; u, Upthrown side
EMF Property Lines
NOTE: Map adapted from Trimble, 1976
0 1 2
SCALE IN MILES
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Regional Geology
21372
FIGURE 3.1-2a
MICHAUD FLATS
SNAKE RIVER PLAIN
PORTNEUF
POCATELLO MUNICIPAL AIRPORT
Batch Springs
86
15
FMC FACILITY
SIMPLOT FACILITY
MICHAUD CREEK
POCATELLO
Qm
Qal
Ql
Qoa
Qa
Qf
Qg
Tu
pЄ

QUATERNARY PERIOD

Holocene Epoch

Qal	YOUNGER ALLUVIUM - sand, silt, and gravel fluvial, alluvial, colluvial, and aeolian deposits in active stream channels and mantling alluvial fans
Ql	LOESS - Aeolian deposit of silts.
Qalo	OLDER ALLUVIUM - sand, silt, and gravel fluvial, alluvial, colluvial, and aeolian deposits in abandoned channels and older terraces.

Late-Pleistocene Epoch

Qa	ABERDEEN TERRACE DEPOSITS - pebble gravel fluvial deposits of mostly reworked Michaud Gravel.
Qm	MICHAUD GRAVEL - rounded gravel, boulder, sand fluvial deposits of ancient Bonneville flood.
Qam	AMERICAN FALLS LAKE BEDS - mostly silt and clay lacustrine deposits of ancient American Falls Lake which was created by a basalt dam on the Snake River.
Qs	SUNBEAM FORMATION - mostly unbedded to poorly bedded calcareous silt, sand, and gravel alluvial and colluvial deposits surrounding ancient American Falls Lake which was created by a basalt dam on the Snake River. Not exposed in study area.
Qb	BIG HOLE BASALT - dense blue-gray to blue-black basalt deposited at about the same time as a number of other basalt flows in the region, one of which dammed the Snake River near American Falls. Not exposed in study area.
Qr	RAFT FORMATION - clay to gravel lacustrine, fluvial, and alluvial deposits related to ancient Raft Lake which was created by a basalt dam on the Snake River near the confluence of the Raft River. Not exposed in study area.
Qg	PEDIMENT GRAVELS - gravel and boulder aprons mantling pediment surfaces cut on Tertiary rock adjacent to the Bannock and Pocatello Ranges.

UNCONFORMITY

TERTIARY PERIOD

Late-Miocene to Pliocene Epoch

Tu	STARLIGHT FORMATION (undifferentiated) - mostly bedded rhyolitic tuff with interbedded ashflow, rhyolite tuff, basaltic tuff and flows, vitrophyre, trachyandesite, and sedimentary deposits including conglomerate and breccia.

UNCONFORMITY

PRE-TERTIARY PERIOD

PRECAMBRIAN TO CAMBRIAN PERIOD

pCu-Cu	BASEMENT COMPLEX (undifferentiated) - metamorphosed to unmetamorphosed marine sedimentary (carbonates and fine- to coarse-grained clastics) and volcanic rocks.

93-1477c.123/DW/R0

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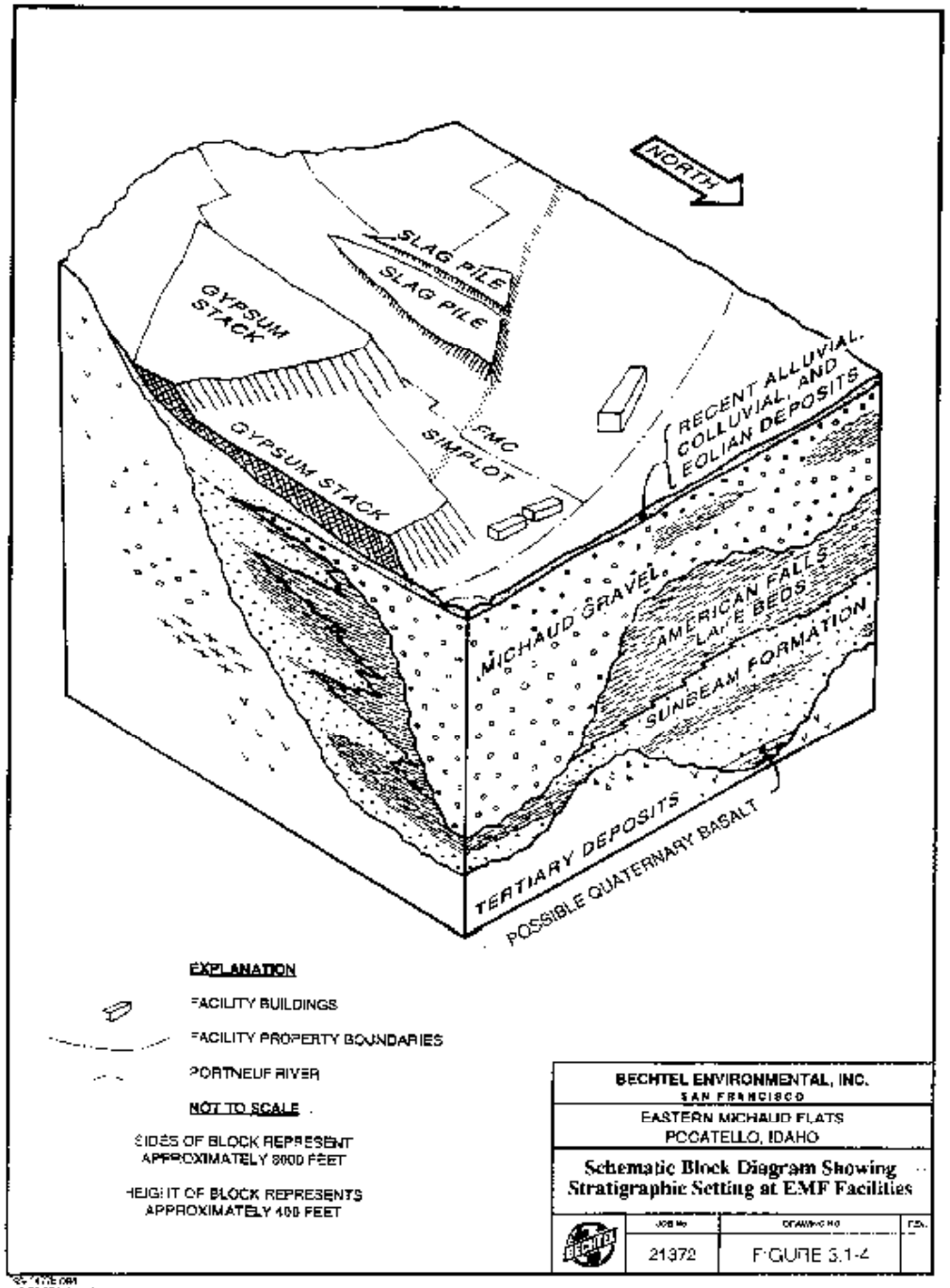
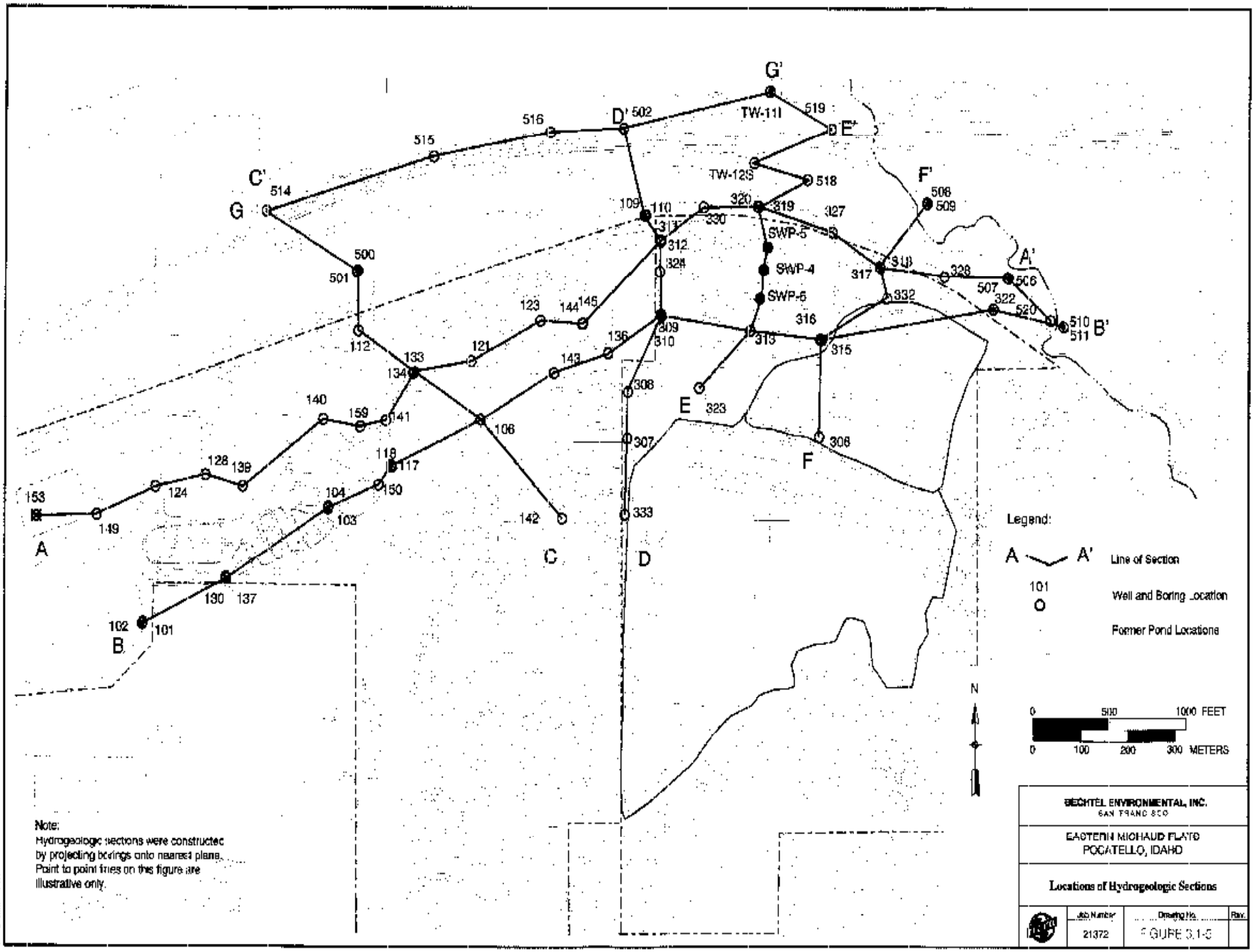
SAN FRANCISCO

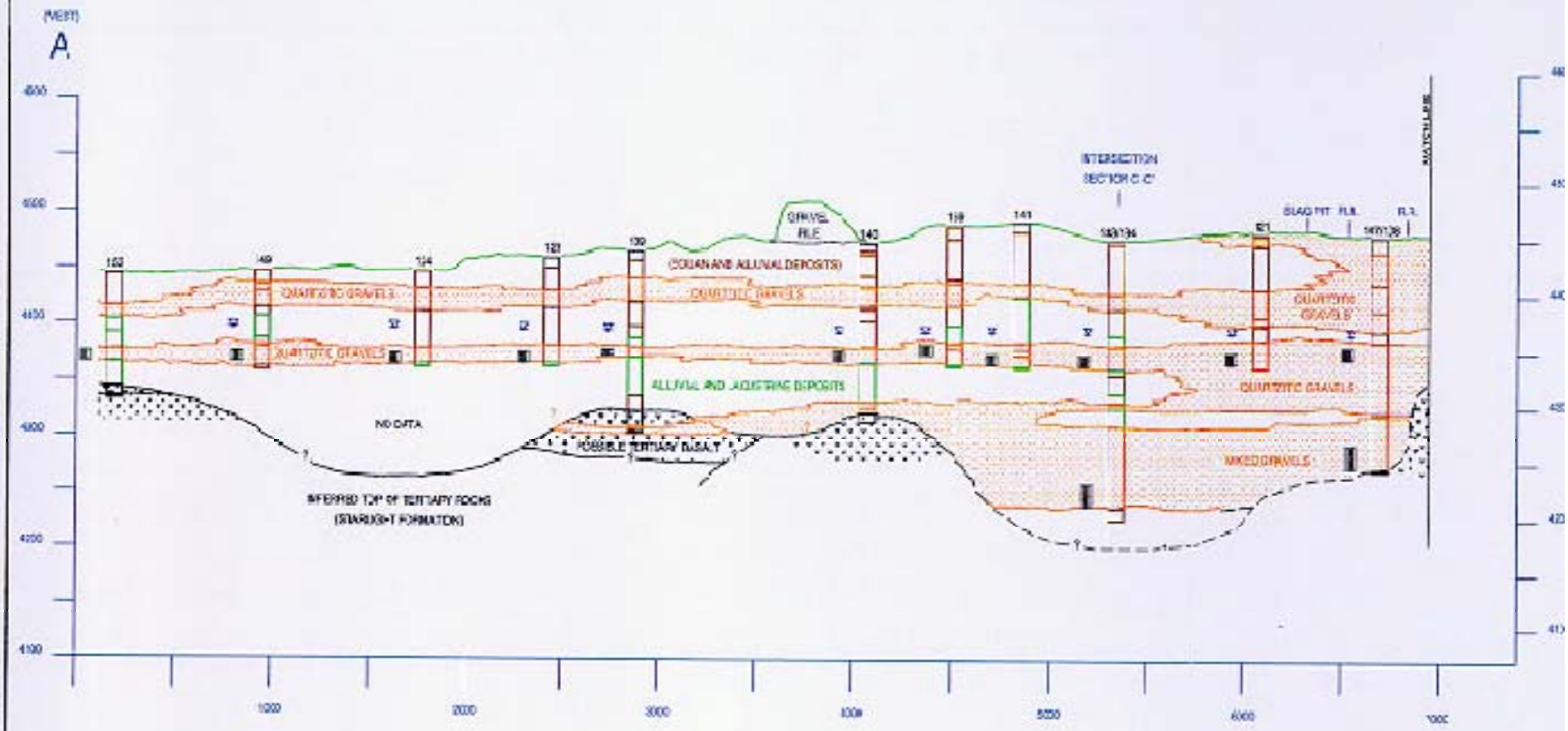
EASTERN MICHAUD FLATS
POCATELLO, IDAHO

General Area Stratigraphy


NORTH
SLAG PILE
SLAG PILE
GYPSUM STACK
GYPSUM STACK
FMC SIMPLOT
RECENT ALLUVIAL, COLLUVIAL, AND EOLIAN DEPOSITS
MICHAUD GRAVEL
AMERICAN FALLS LAKE BEDS
SUNBEAM FORMATION
TERTIARY DEPOSITS
POSSIBLE QUATERNARY BASALT
EXPLANATION
FACILITY BUILDINGS
FACILITY PROPERTY BOUNDARIES
PORTNEUF RIVER
NOT TO SCALE
SIDES OF BLOCK REPRESENT APPROXIMATELY 8000 FEET
HEIGHT OF BLOCK REPRESENTS APPROXIMATELY 400 FEET
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Schematic Block Diagram Showing Stratigraphic Setting at EMF Facilities
21372
FIGURE 3.1-4



Note:
Hydrogeologic sections were constructed by projecting borings onto nearest plane. Point to point lines on the figure are illustrative only.



Legend

- Water level
- Well screen

SAND
GRAVELLY SAND
SILTY SAND
CLAYEY SAND
SANDSTONE
GRAVEL
SAND AND GRAVEL
SILTY, SANDY GRAVEL
SILTY GRAVEL
CLAYEY GRAVEL

SILT
CLAYEY SILT
SANDY SILT
GRAVELLY SILT

CLAY
SILTY CLAY
SANDY CLAY
GRAVELLY CLAY

BASALT
RHYOLITE
TUFF

CALICHE
PEAT

ASPHALT
CONCRETE
FILL

NOTES:

1) Ground surface line is generalized
2) Vertical exaggeration = 5x
3) Cross-section is generalized. See boring logs in Appendix for further details.

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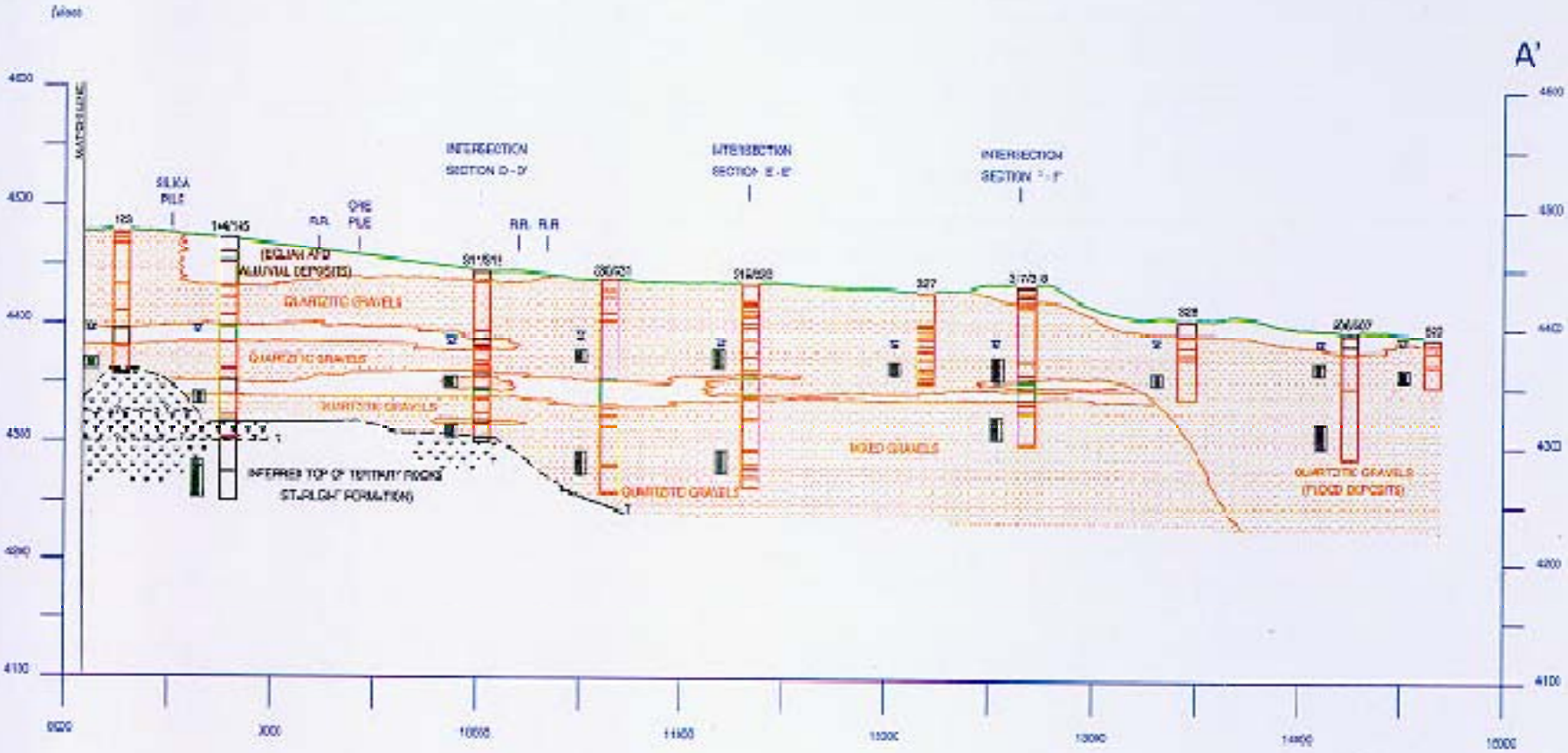
EASTERN HIGHLAND FLATS
POCATELLO, IDAHO

Hydrogeologic Cross-Section A-A'
sheet 1 of 2

Job Number	Drawing No.	Rev
21372	FIGURE 3.16A	



Legend:

- Water Level
- Not Screen

SAND
GRAVELLY SAND
SILTY SAND
PLAYEY SAND
SANDSTONE
GRAVEL
SAND AND GRAVEL
SILTY, SANDY GRAVEL
SILTY GRAVEL
CLAYEY GRAVEL

SILT
CLAYEY SILT
SANDY SILT
GRAVELLY SILT

CLAY
SILTY CLAY
SANDY CLAY
GRAVELLY CLAY

BASALT
TRAVERTINE
TUFF

CALICHE
PEAT

ASPHALT
CONCRETE
FILL

NOTES:

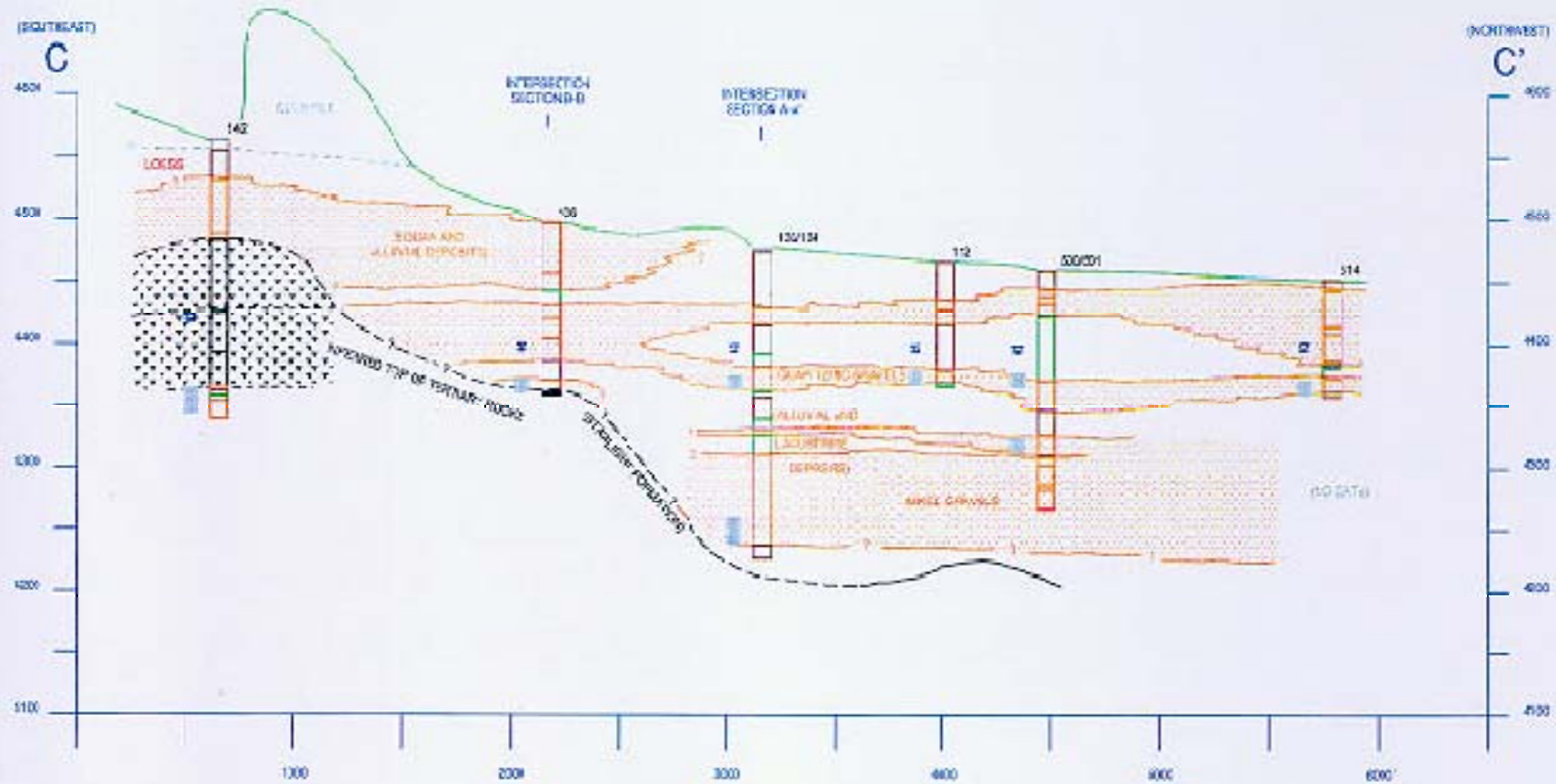
1) Ground surface line is generalized
2) Vertical exaggeration - 6x
3) Cross-section is generalized. See boring logs in Appendix for further details.

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN IDAHO FLATS
POCATELLO, IDAHO

Hydrogeologic Cross-Section A-A'
sheet 2 of 2

Job Number	Drawing No.	Rev
21572	FIGURE 3.14E	



Notes:

1) Ground surface line is generalized.

2) Vertical exaggeration = 5x

3) Cross section is generalized.
See boring logs in Appendix for further details.

Legend

Water level

Well screen

SAND
GRAVELLY SAND
SILTY SAND
CLAYEY SAND
SANDSTONE
GRAVEL
SAND AND GRAVEL
SILTY SAND GRAVEL
SILTY GRAVEL
CLAYEY GRAVEL

SILT
CLAYEY SILT
SANDY SILT
GRAVELLY SILT

CLAY
SILTY CLAY
SANDY CLAY
GRAVELLY CLAY

BASALT
RHYOLITE
TUFF

BALCHE
PEAT

FILL

EECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Hydrogeologic Cross-Section C-C'

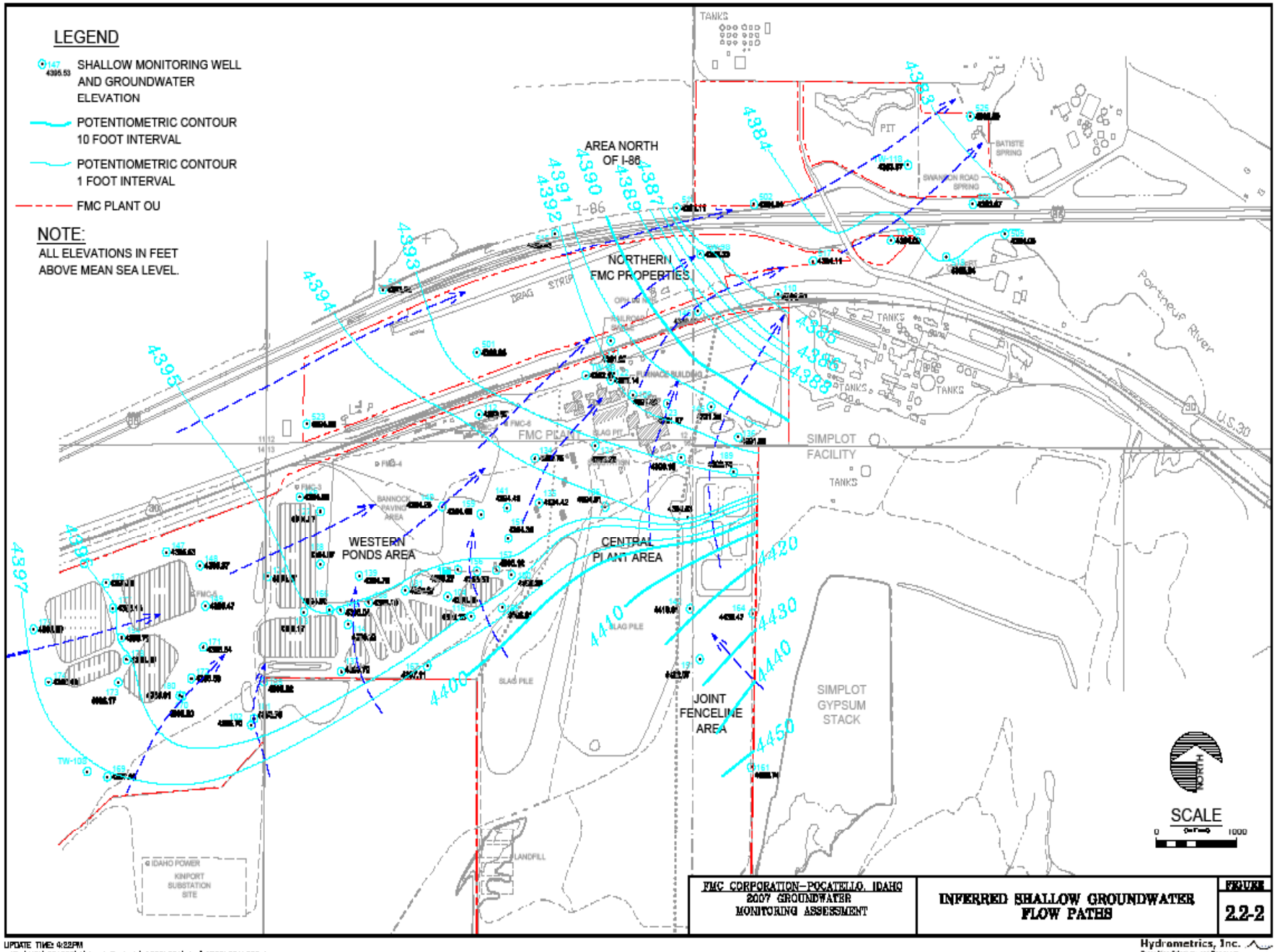
Job Number	Drawing No.
21372	FIGURE 3.14

Hydrogeologic

- Groundwater gradients within the EMF study area are very stable and have not changed significantly, as demonstrated by 18 years of quarterly monitoring (approx.100 FMC wells and 100 Simplot wells).
- Decreased (virtually ceased) extraction at the FMC production wells after the plant shutdown in 2001 had no observable effect on groundwater gradients in the EMF study area.

Hydrogeologic

- Northward flow of groundwater from the western ponds area and central plant areas of the FMC Plant Site is limited to the area south of I-86, due to the effects of converging flow of groundwater from the Michaud aquifer to west and northwest.
- Virtually all groundwater underflowing the EMF facilities discharges to the Portneuf River at Batiste Spring, the Spring at Batiste Road (aka Swanson Road Springs), and as bank seeps and baseflow to the river in the reach bounded by these springs.



FMC CORPORATION–POCATELLO, IDAHO
2007 GROUNDWATER MONITORING ASSESSMENT

INFERRED SHALLOW GROUNDWATER FLOW PATHS

FIGURE 2.2-2

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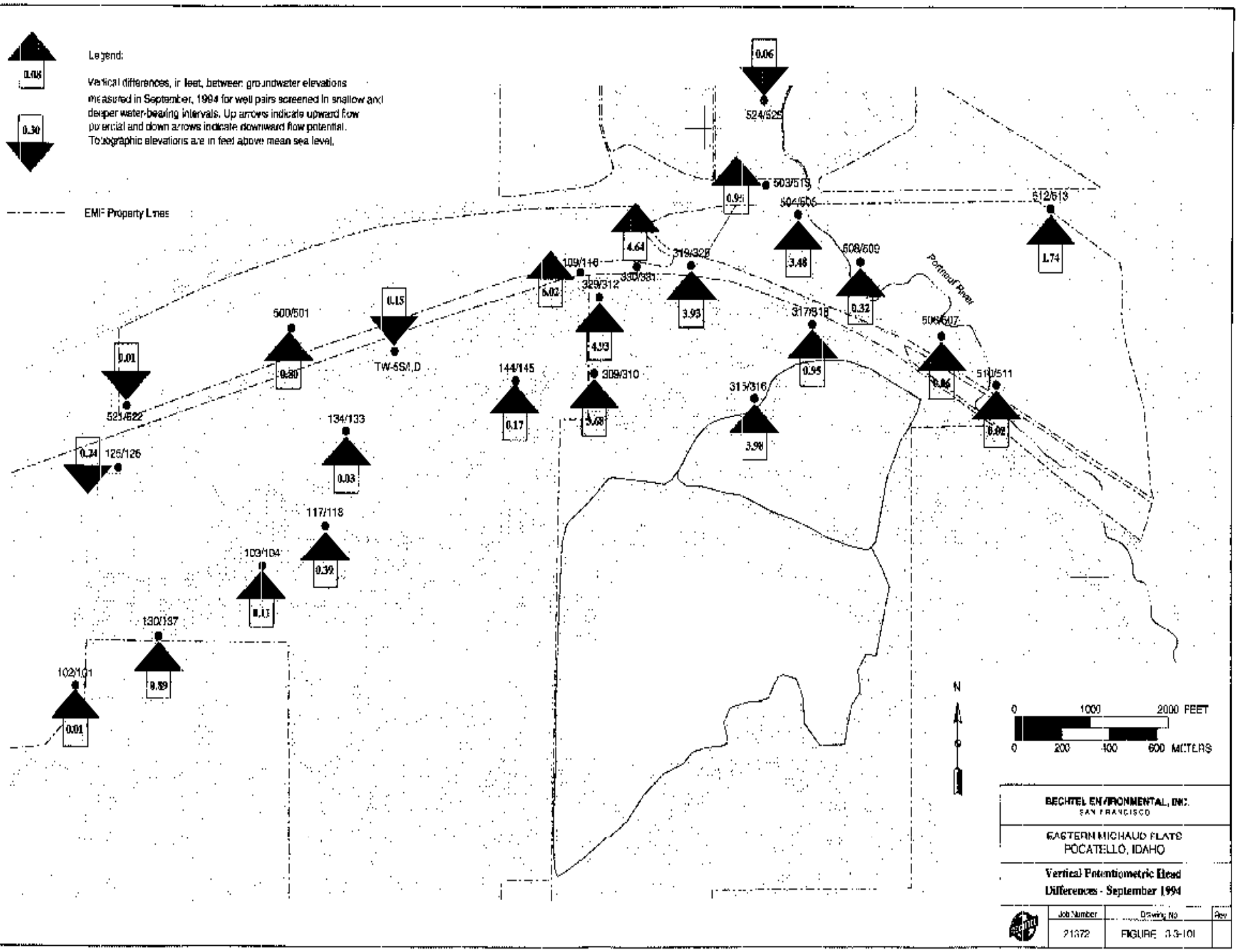
Hydrometrics, Inc.

Hydrogeology

- Migration of site-related constituents from the shallow groundwater zone to the deeper zone is inhibited by upward vertical hydraulic gradients.


Legend:
Vertical differences, in feet, between groundwater elevations measured in September, 1994 for well pairs screened in shallow and deeper water-bearing intervals. Up arrows indicate upward flow potential and down arrows indicate downward flow potential. Topographic elevations are in feet above mean sea level.
0.08
0.30
EMF Property Lines
0.06
524/525
503/513
0.94
504/506
3.48
512/513
1.74
4.64
319/320
3.93
109/146
330/331
329/312
5.02
4.93
309/310
5.08
508/509
0.32
Portneuf River
317/318
0.95
313/316
3.98
505/507
0.86
510/511
0.92
0.15
TW-5S/I,D
500/501
0.80
0.01
521/522
0.34
125/126
134/133
0.03
144/145
0.17
117/118
0.39
103/104
0.11
130/137
0.89
102/101
0.01
N
0 1000 2000 FEET
0 200 400 600 METERS
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Vertical Potentiometric Head Differences - September 1994
Job Number
21372
Drawing No
FIGURE 3.3-101
Rev

Portneuf River

- EMF RI and IDEQ evaluations of the Portneuf River identified the river is a loosing reach generally south of I-86 and becomes gaining reach north of I-86.
- RI and IDEQ evaluations estimated groundwater contribution to river flow in the reach between I-86 and Batiste Spring.

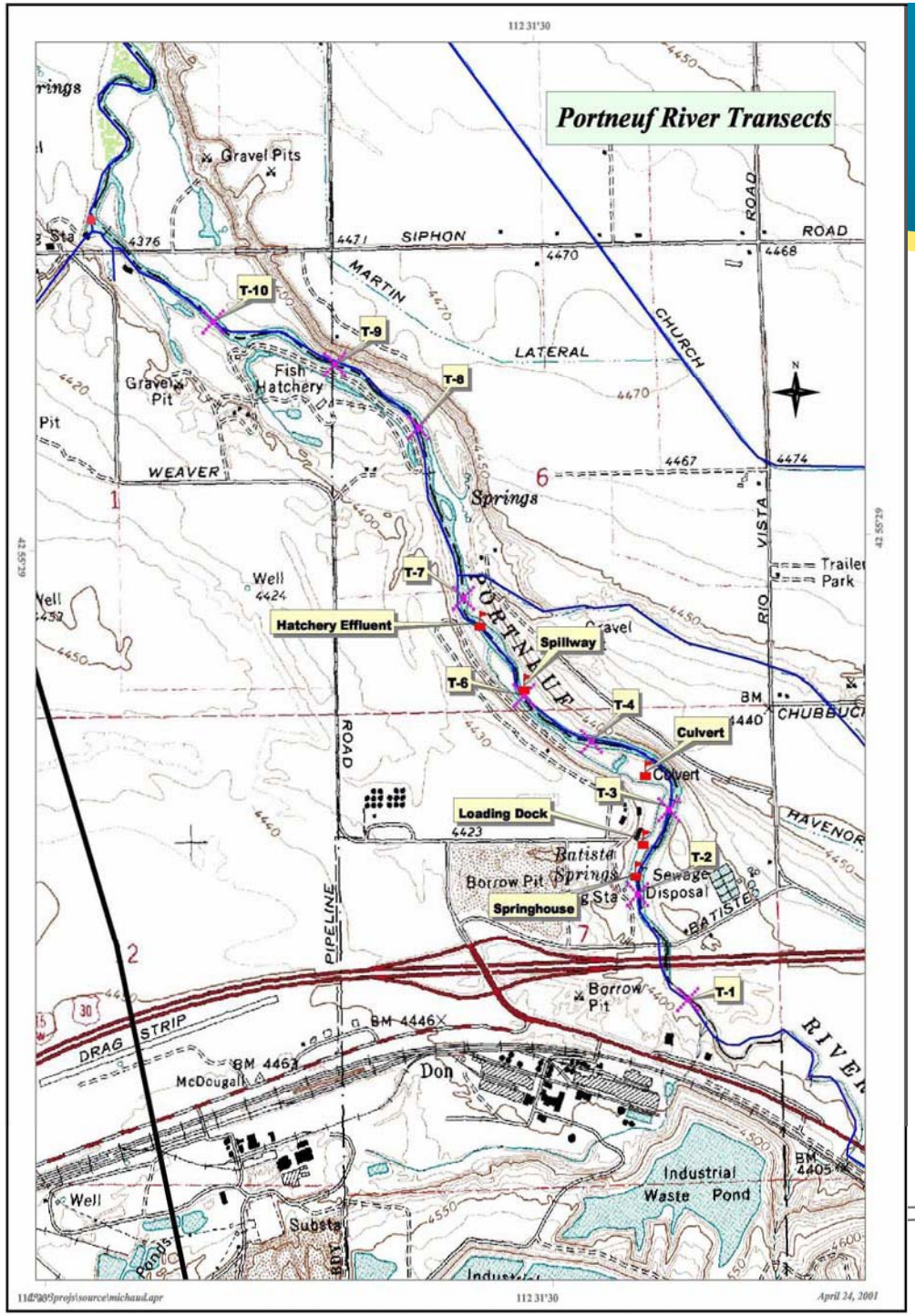


Figure 7. Transect locations sampled along the Portneuf River on September 13 and 14, 2000. Also shown are five Batiste Spring channel locations sampled from May 4, 1999 through December 7, 2000. (IDEQ, January 2004)

Estimated Gain in Portneuf River

- Portneuf discharge at I-86 bridge (1990-2008 averages)
  May peak = 444 cfs; August min = 57 cfs
- Portneuf discharge at Siphon Road (1990-2008 averages)
  April peak = 556 cfs; July min = 154 cfs
- EMF RI estimated 74 cfs in reach between I-86 and downstream from Batiste Spring.
- IDEQ estimates for reach between stations T-1 (south of I-86) and T-3 (downstream from Batiste Spring).
  9/2000 – 62 cfs
  8/2001 – 58 cfs
  9/2002 – 68 cfs
- Half of gain estimated to originate from west (“EMF”) side of the river (Simplot, November 2008).

Groundwater Impacts

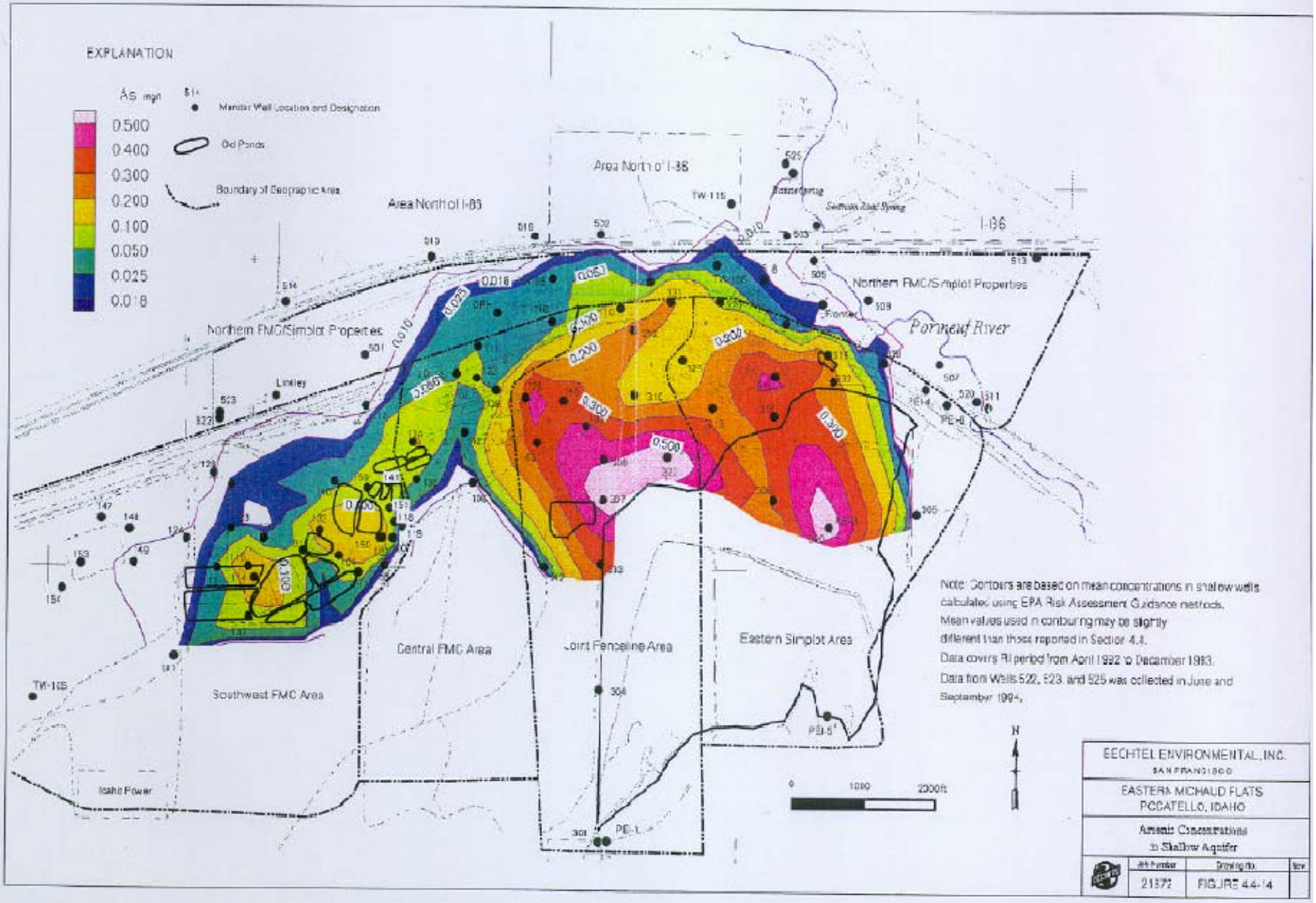
FMC Sources

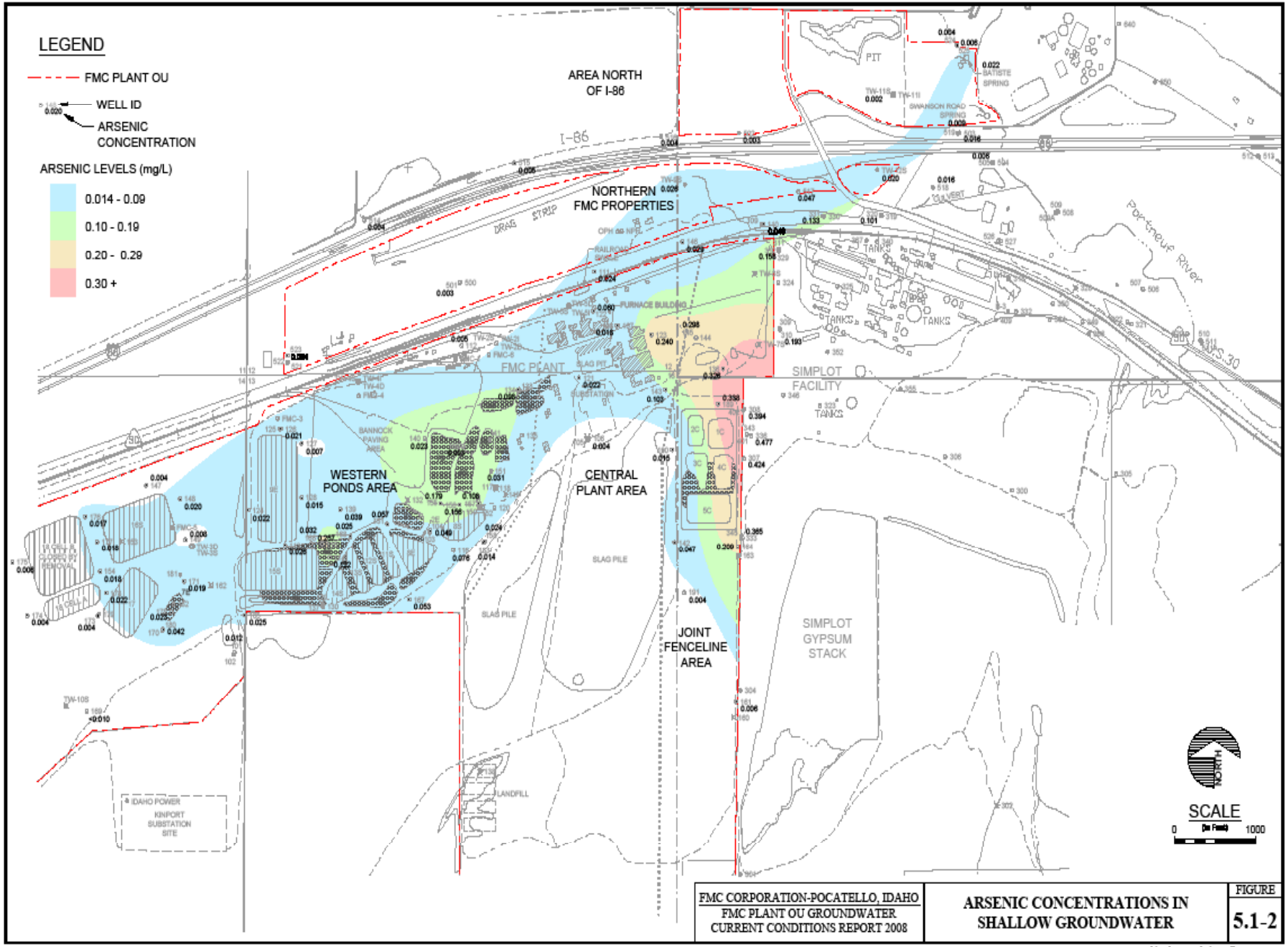
- Former unlined ponds with sustained hydraulic head are primary FMC source areas (e.g., former Pond 8S, former unlined calciner ponds)
- Dissolved inorganic constituents associated with phosphate shale
  - Common ions (potassium, chloride, sulfate)
  - Nutrients (total phosphorus, ammonia, nitrate)
  - Metals (arsenic, manganese, selenium)
- Alkaline / calcareous soils limited mobility of heavy metals

Contaminant Source Areas

Simplot Sources

- Unlined Upper and Lower Gypsum Stacks operated with sustained hydraulic head
- Dissolved inorganic constituents associated with phosphate shale
  - Common ions (sulfate, sodium, magnesium)
  - Nutrients (total phosphorus)
  - Metals (arsenic)
- Phosphoric Acid Plant (PAP) - Total phosphorus, ammonia, nitrate, low pH mobilizes heavy metals (e.g., nickel)


EXPLANATION
As mg/l
0.500
0.400
0.300
0.200
0.100
0.050
0.025
0.018
Monitor Well Location and Designation
Old Ponds
Boundary of Geographic Area
Area North of I-86
Area North of I-86
I-86
Northern FMC/Simplot Properties
Northern FMC/Simplot Properties
Portneuf River
Linkley
Southwest FMC Area
Central FMC Area
Joint Fenceline Area
Eastern Simplot Area
Idaho Power
Note: Contours are based on mean concentrations in shallow wells calculated using EPA Risk Assessment Guidance methods. Mean values used in contouring may be slightly different than those reported in Section 4.4. Data covers RI period from April 1992 to December 1993. Data from Wells 522, 523, and 525 was collected in June and September 1994.
0 1000 2000ft
N
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Arsenic Concentrations
in Shallow Aquifer
Job Number
21372
Drawing No.
FIGURE 4.4-14
Rev



FMC CORPORATION-POCATELLO, IDAHO FMC PLANT OU GROUNDWATER CURRENT CONDITIONS REPORT 2008	ARSENIC CONCENTRATIONS IN SHALLOW GROUNDWATER	FIGURE 5.1-2

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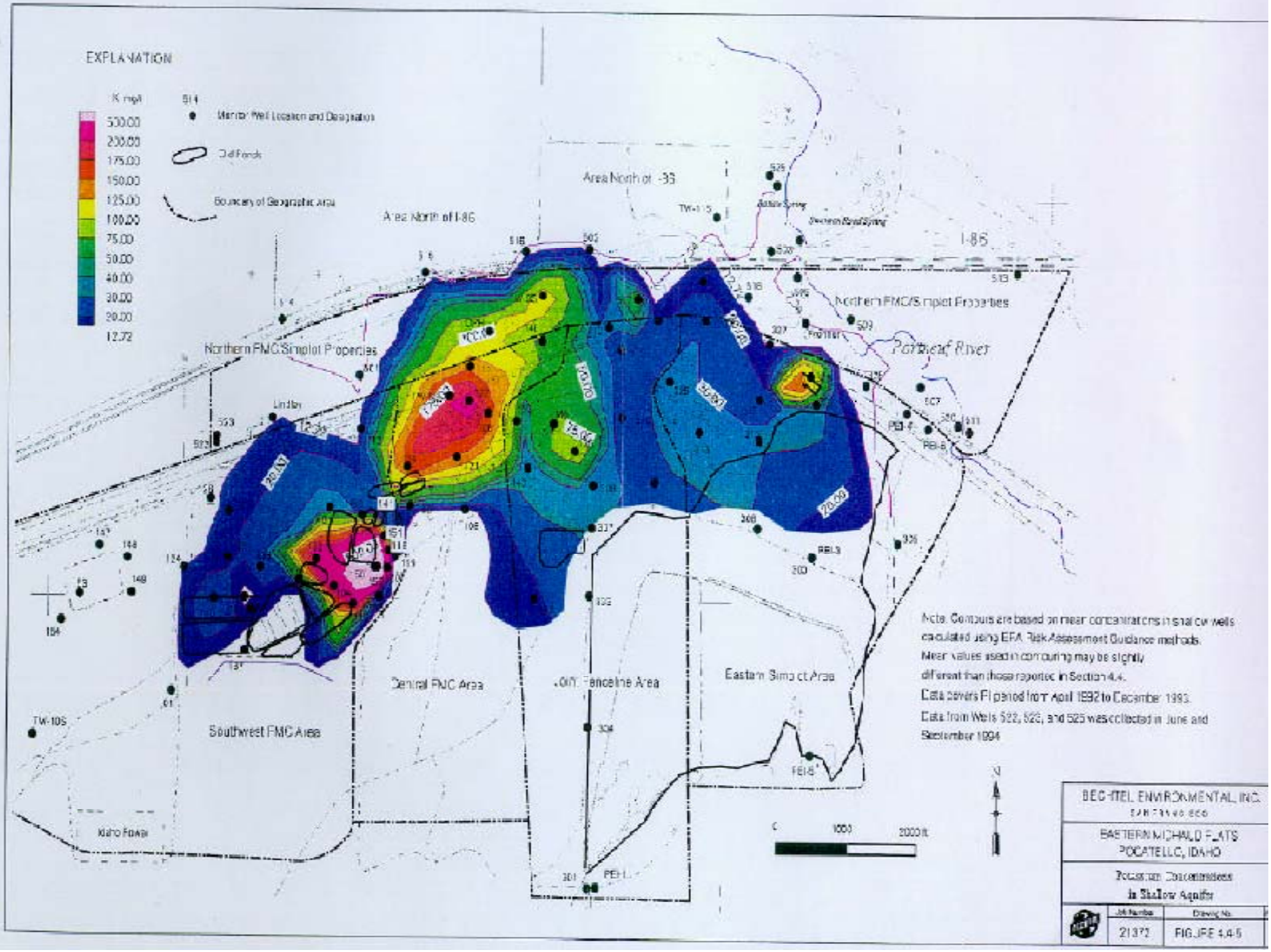
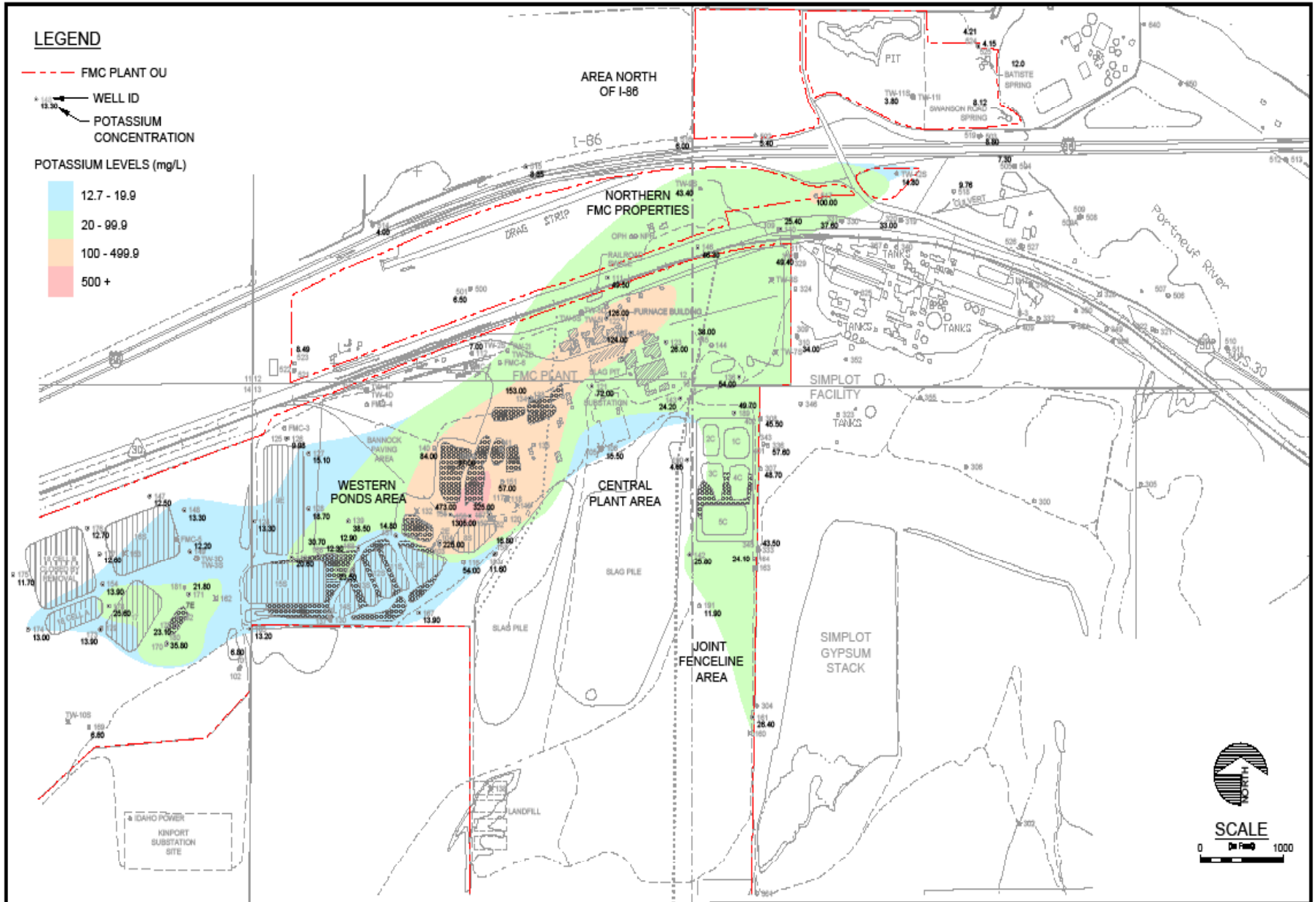
Hydrometrics, Inc.


EXPLANATION
K mg/l
500.00
200.00
175.00
150.00
125.00
100.00
75.00
50.00
40.00
30.00
20.00
12.72
Monitor Well Location and Designation
Oil Ponds
Boundary of Geographic Area
Area North of I-86
Area North of I-86
I-86
Northern FMC/Simplot Properties
Northern FMC/Simplot Properties
Portneuf River
Lindsay
Central FMC Area
Off Fenceline Area
Eastern Simplot Area
Southwest FMC Area
Idaho Power
TW-10S
Note: Contours are based on mean concentrations in shallow wells calculated using EPA Risk Assessment Guidance methods. Mean values used in contouring may be slightly different than those reported in Section 4.4.
Data covers the period from April 1992 to December 1993.
Data from Wells 522, 523, and 525 was collected in June and September 1994
0
1000
2000 ft
N
BEC-TEL ENVIRONMENTAL, INC.
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Fluoride Concentrations
in Shallow Aquifer
Job Number
21372
Drawing No.
FIGURE 4.4-5



FMC CORPORATION-POCATELLO, IDAHO FMC PLANT OU GROUNDWATER CURRENT CONDITIONS REPORT 2008	POTASSIUM CONCENTRATIONS IN SHALLOW GROUNDWATER	FIGURE 5.1-3

UPDATE TIME: 11:01 AM
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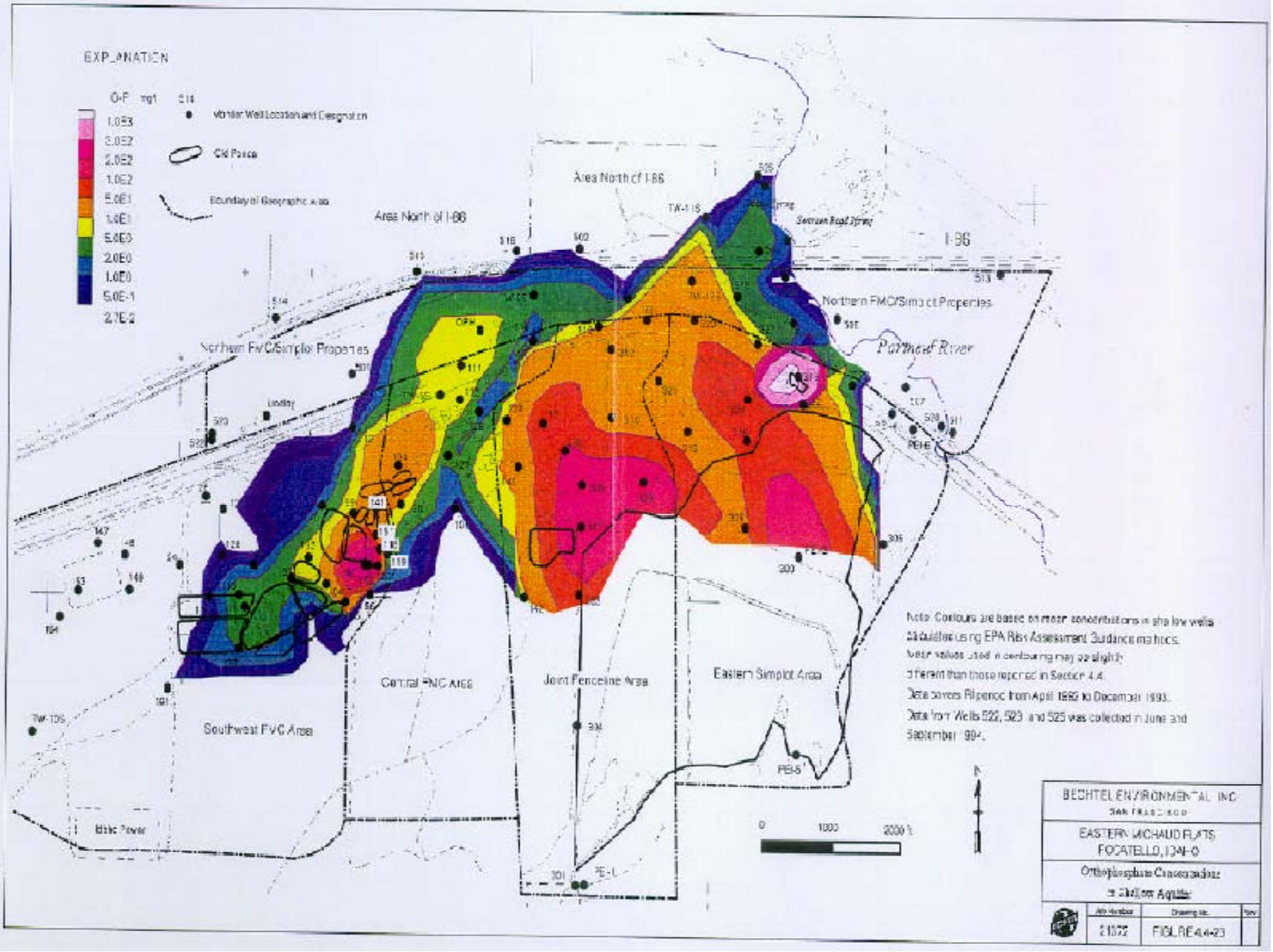
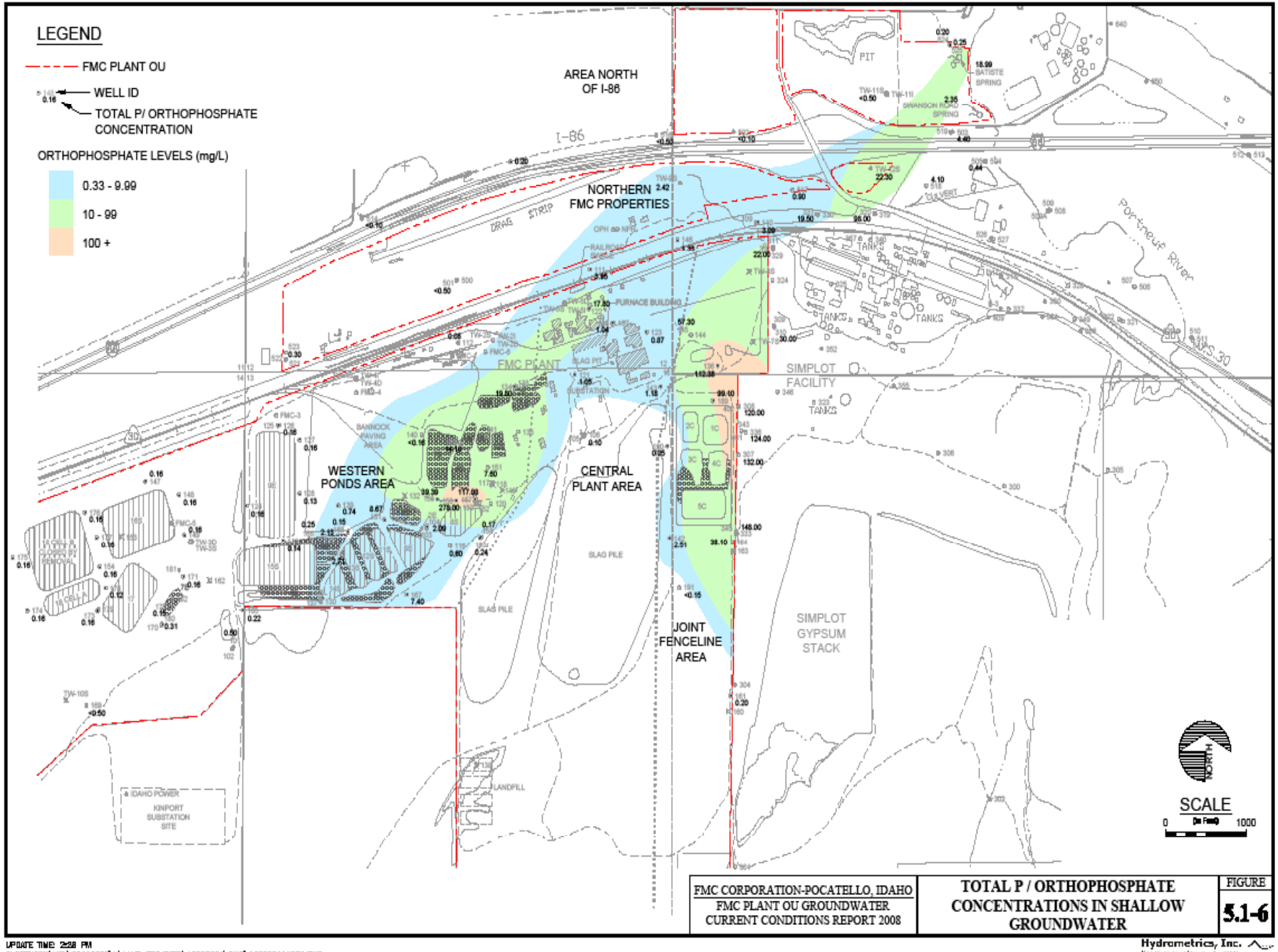
Hydrometrics, Inc.


EXPLANATION
O-P mg/l
1.0E3
3.0E2
2.0E2
1.0E2
5.0E1
1.0E1
5.0E0
2.0E0
1.0E0
5.0E-1
2.7E-2
Monitor Well Location and Designation
Old Pond
Boundary of Geographic Area
Area North of I-86
Area North of I-86
I-86
Northern FMC/Simplot Properties
Northern FMC/Simplot Properties
Portneuf River
Southwest FMC Area
Central FMC Area
Joint Fenceline Area
Eastern Simplot Area
Note: Contours are based on mean concentrations in shallow wells as calculated using EPA Risk Assessment Guidance methods. Mean values used in contouring may be slightly different than those reported in Section 4.4.
Data covers Rilpence from April 1992 to December 1993.
Data from Wells 522, 523 and 525 was collected in June and September 1994.
0
1000
2000 ft
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Orthophosphate Concentration in Shallow Aquifer
Job Number
21072
Drawing No.
FIGURE 4.4-23
Rev



FMC CORPORATION-POCATELLO, IDAHO
FMC PLANT OU GROUNDWATER
CURRENT CONDITIONS REPORT 2008

TOTAL P / ORTHOPHOSPHATE CONCENTRATIONS IN SHALLOW GROUNDWATER

FIGURE
5.1-6

UPDATE TIME: 2:28 PM
GLORENSON\HEL\20080320\I:\LAND PROJECTS\13038201\DWG\13038201H070.DWG

Hydrometrics, Inc.

Summary

Hydrogeology is relatively complex

- Upper groundwater zone includes fine grained units and discontinuous alluvial lenses.
- American Falls Lake Bed is a laterally extensive but discontinuous aquitard.
- Lower groundwater zone includes fine grained units, gravels and volcanic bedrock units.
- Michaud gravel is prolific in the area of the Portneuf River.

Summary (Continued)

Groundwater System is very stable

- Groundwater gradient does not vary significantly seasonally or over multi-year period (18+ years data)
- Upward vertical gradient from lower to upper groundwater zone consistent year-over-year.
- Groundwater gradient not observably impacted by changes in pumping from deep zone.
- EMF groundwater merges with the Portneuf River within the gaining reach between and including Swanson Road and Batiste Springs.

Summary (Continued)

Site-Related Groundwater Impacts

- Nature and extent of site-impacted groundwater well defined (over 200 wells and 18+ years monitoring)
- Site plume “defined” by arsenic concentrations above MCL
- Significant total phosphorus plumes from the Simplot gypsum stack and PAP and the FMC former Pond 8S
- Potassium is reliable indicator for discriminating FMC sources from Simplot sources

FMC
Supplemental Feasibility Study
Groundwater Modeling Update

July 1, 2009
Pocatello, Idaho

MWH

BUILDING A BETTER WORLD

Modeling Objectives

- Development of a tool that can support the Supplemental Feasibility Study and compare remedial alternatives for the FMC Plant Operable Unit of the Eastern Michaud Flats Superfund Site
- Groundwater flow model will be used to provide the underlying flow regime for contaminant fate and transport simulations

Model Codes

MODFLOW

- Finite difference model developed by the USGS
- Employed to simulate saturated groundwater flow at the site

MODPATH

- Advective transport model (particle tracking) developed by USGS
- Employed to visualize groundwater flow paths, delineate capture zones, and determine advective transport velocities at the site

MT3DMS

- Advective/dispersive transport model developed by US EPA
- Integrates with MODFLOW groundwater flow solution
- Will be employed to simulate transport of contaminants in the saturated zone
- Can simulate the effects of advection, dispersion, dilution, retardation, and degradation of contaminants

Flow Model Construction

Domain

Grid

Layering

Boundary Conditions

Parameter Values

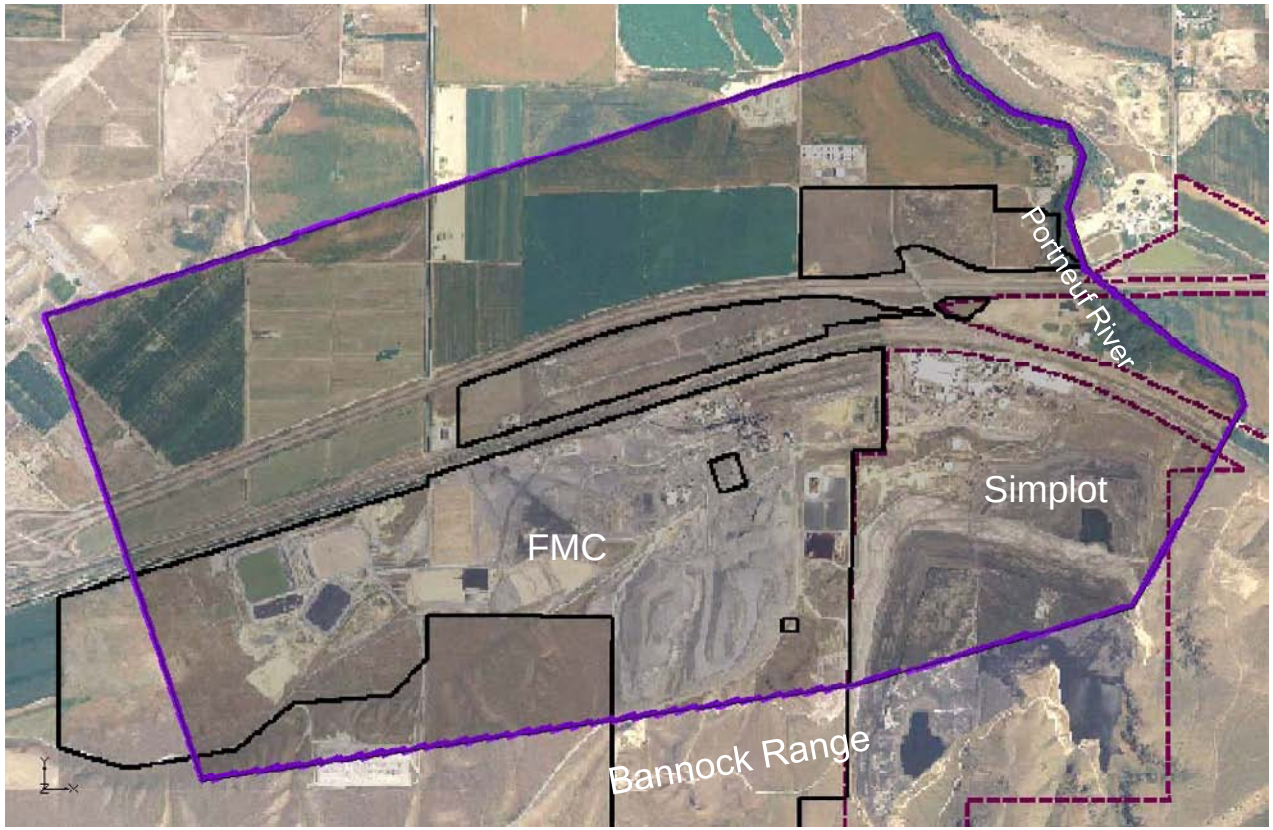
Calibration

Sensitivity Analysis

Domain

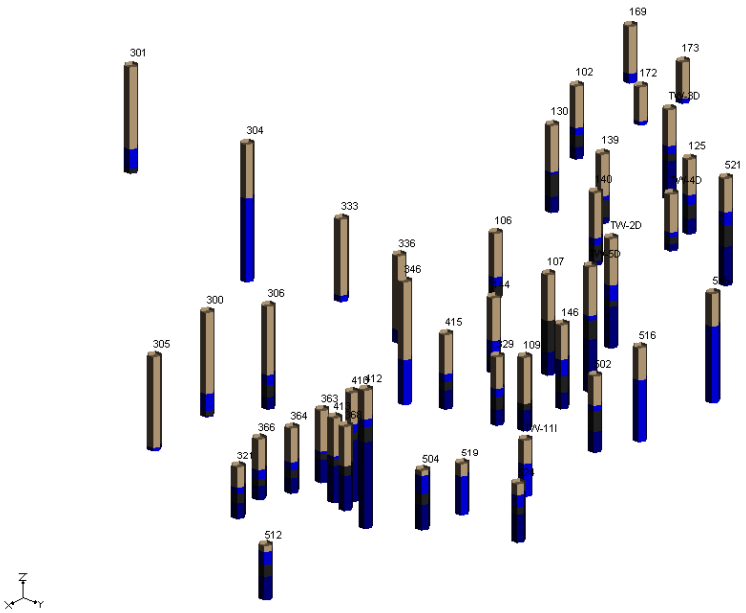
Approximately 15,500 by 9,000 feet – 2,862 acres

50 ft by 50 ft cells (50,463 per layer – total 201,852 cells)



Layering

BOREHOLE DATA FROM 130 WELLS



MODEL LAYERS

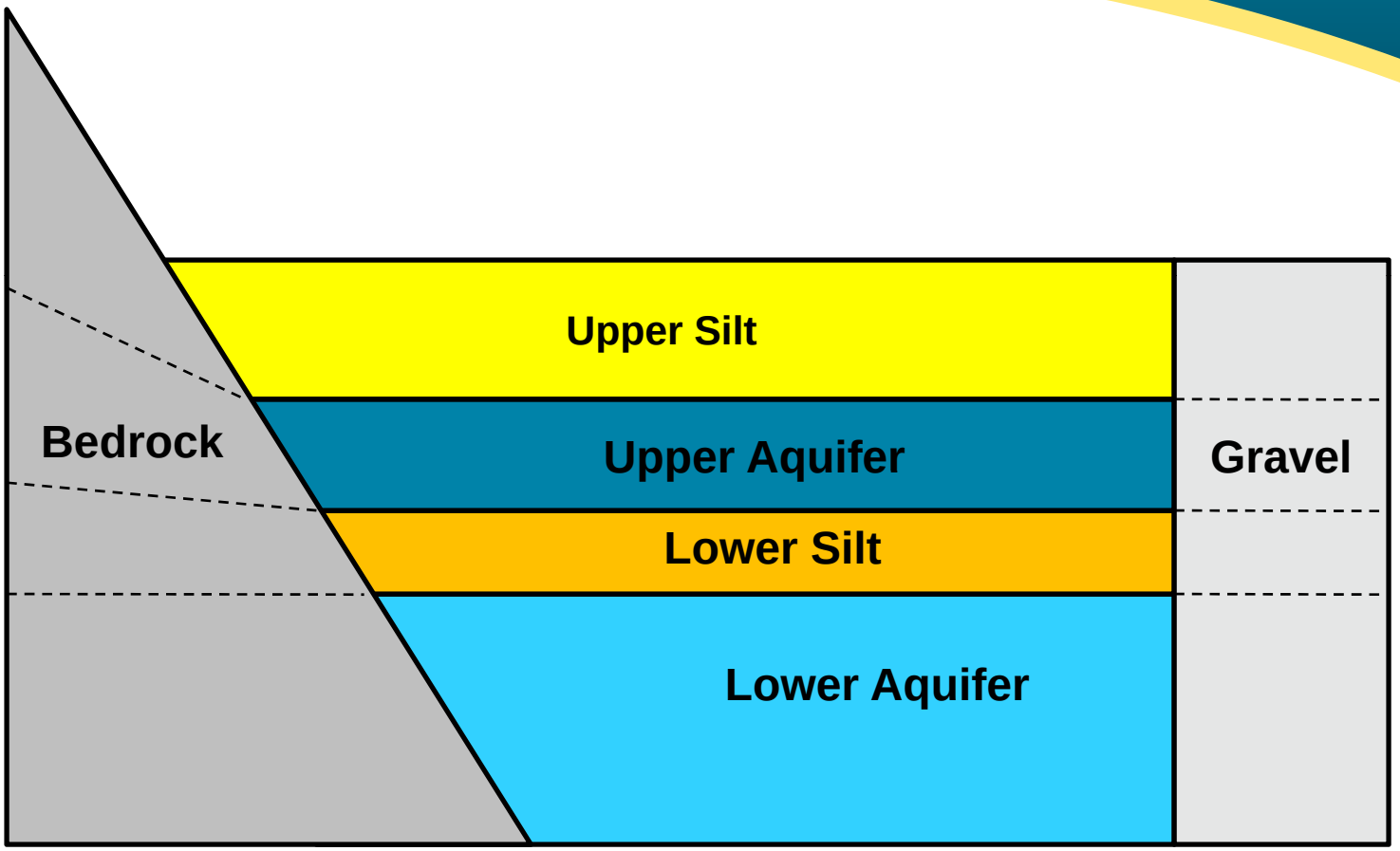
Layering

In general, the model layering scheme is based upon the major hydrogeologic units identified in the RI:

- Layer 1 = Upper Silt/volcanic bedrock/gravel
- Layer 2 = Upper Aquifer Zone/volcanic bedrock/gravel
- Layer 3 = Lower Silt/volcanic bedrock/gravel
- Layer 4 = Lower Aquifer Zone/volcanic bedrock/gravel

Clear distinctions between units are not always present and the vertical discretization is not necessarily based on stratigraphy near the Bannock Range and the Portneuf River

Layering


Upper Silt
Bedrock
Upper Aquifer
Gravel
Lower Silt
Lower Aquifer

Hydraulic Conductivity Distribution

In general, lower conductivities coincide with volcanic bedrock (Bannock Range) while higher conductivities coincide with gravel near the Portneuf River:

Layer 1

- 0.25 to 250 feet/day

Layer 2

- 0.25 to 10,000 feet/day

Layer 3

- 0.25 to 250 feet/day

Layer 4

- 0.25 to 4000 feet/day

Boundary Conditions

Constant Heads

- Employed to simulate Portneuf River and mountain front recharge from Bannock Range (natural hydraulic boundaries)
- Also used to control head distribution along northern and western boundaries (artificial hydraulic boundaries)

Areal Recharge (net recharge)

- Estimated to be 1.1 in/year (10% of average annual precipitation)
- Simplot gyp stack infiltration estimated to be 800 gpm (Simplot, Nov 2008)
- Assumed recharge to aquifer beneath FMC closed RCRA and remediated Calciner ponds to be negligible (2×10^{-5} in/year)

Batiste and Swanson Road Spring

- Simulated with MODFLOW Drain package

Pumping wells

- Simplot extraction wells (15 wells at ~650 gpm total) and production wells (3 wells at ~3400 gpm total) are included

Flow Model Calibration

Process

- Manual adjustment of hydraulic conductivity values and boundary conditions within measured ranges
- Automated techniques (PEST) were used to refine the calibration
- Simulated water levels were compared to measured water levels (calibration targets)
- Calibration targets were 2008 average water levels from 143 wells across FMC and Simplot sites
- Model calculated flux from Bannock Range recharge and flux to Portneuf River and associated springs was compared to estimated values

Evaluation of Calibration

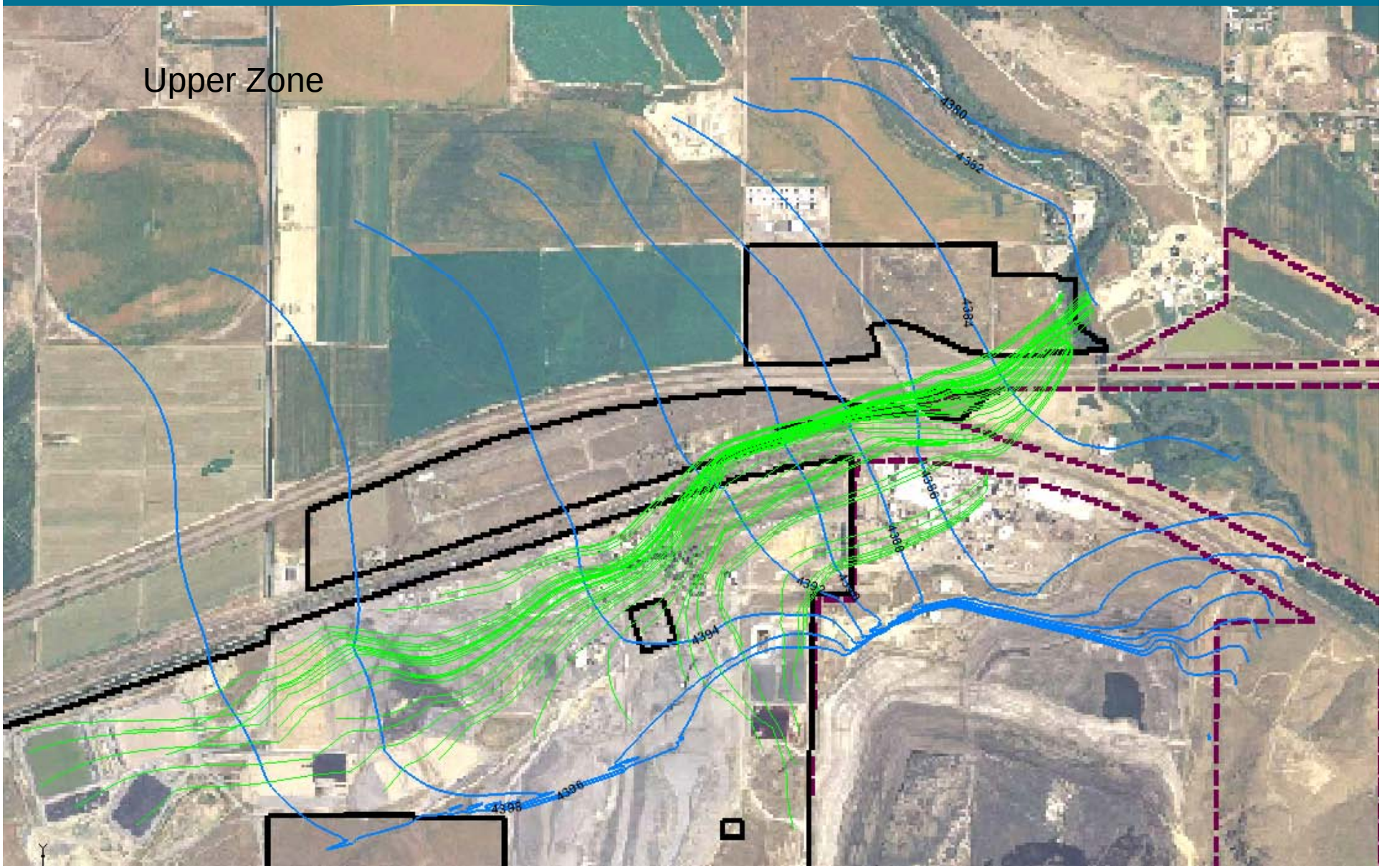
Qualitative Measures

- Potentiometric contour maps
- Particle tracking flow directions

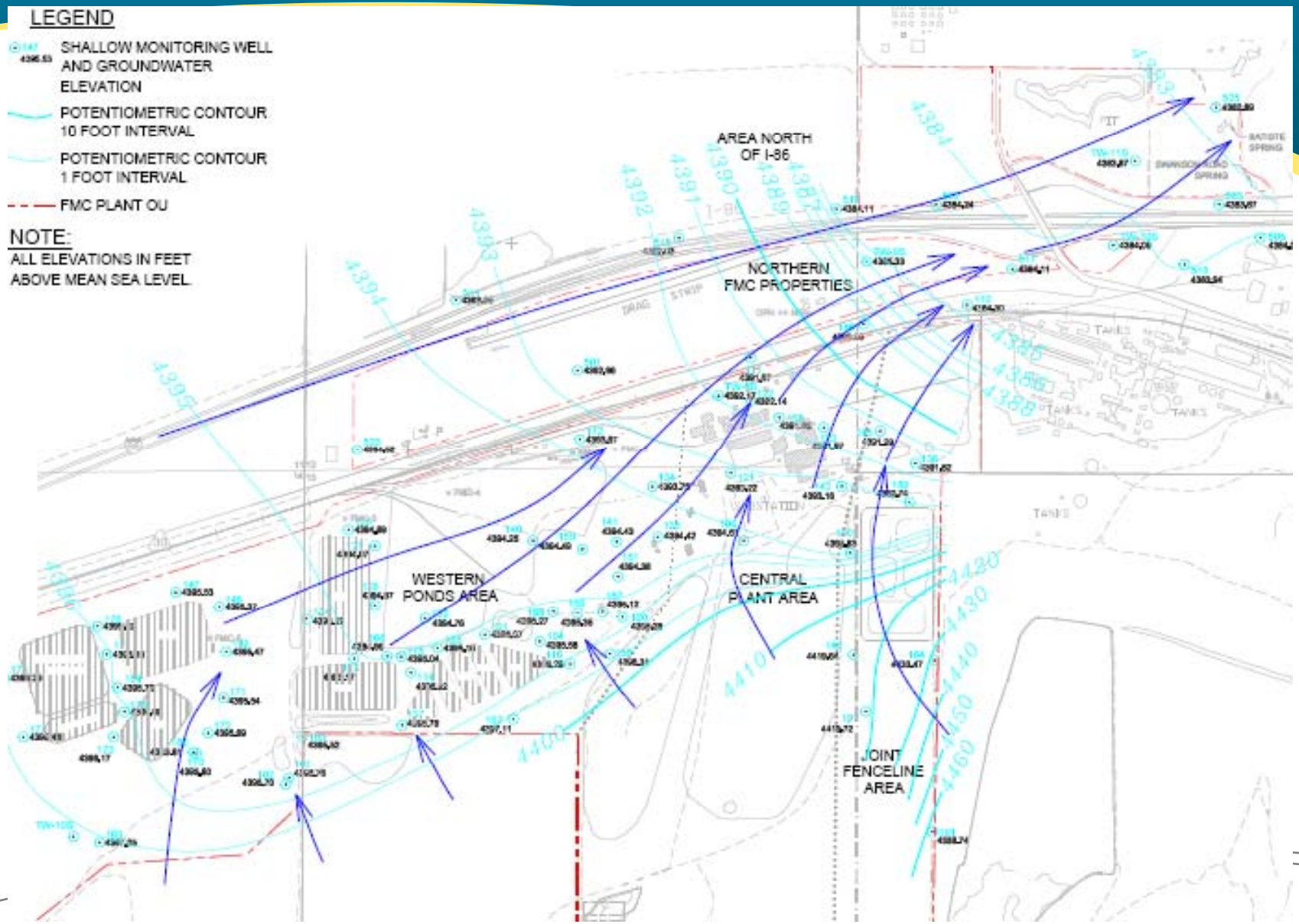
Quantitative Measures

- Distribution and magnitude of errors in water levels
- Average error, absolute average error, and root mean squared error
- Normalized root mean squared error
- Mass balance errors
- Comparison of modeled fluxes to estimates (flux from Bannock Range and flux to Portneuf River)

Simulated Potentiometric Contours



Observed Potentiometric Contours



Preliminary Calibration Statistics

Range of errors = -7.3 ft to +8.3 ft

Average error = -0.2 ft

Absolute average error = 1.1 ft

Root mean squared error = 1.5 ft

Normalized root mean squared error = <1%

Flow Budgets

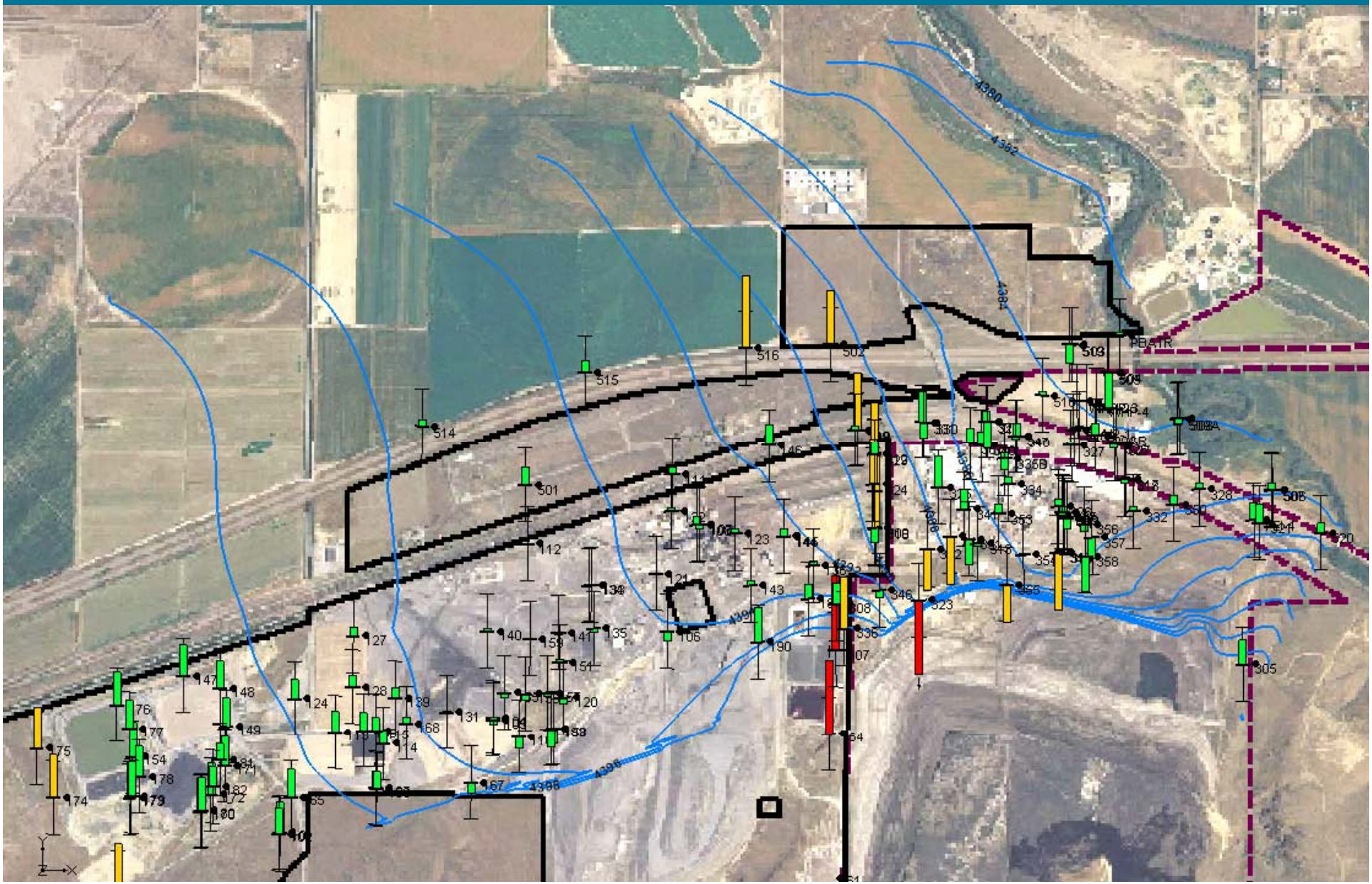
Mass Balance Errors

- 6×10^{-5} %

Boundary Fluxes Within Estimated Ranges:

- Flux to the Portneuf River = ~48 cfs
- Flux to Batiste and Swanson Rd Springs = ~8 cfs
- Flux from Bannock Range = ~7 cfs

Distribution of Errors (Modeled – Observed)



Sensitivity Analysis

Several flow parameters will be modified within reasonable ranges to assess the model's response to uncertainty:

- Hydraulic Conductivity
- Net Recharge
- Spring elevation and conductance
- River stage

Summary

- Flow model is adequately calibrated
- Sensitivity analysis will be conducted and presented in the SFS report
- Transport model development to commence

Contaminant Transport Model Plans

Purpose and Objectives

- To simulate transport of the primary contaminant and indicator parameters
- Support the SFS and remedial alternatives development
- To evaluate and optimize remedial alternatives

Contaminants to be Simulated

- Arsenic
  - Primary risk driving groundwater COC
- Total Phosphorus/Orthophosphate
  - Primary (groundwater to) surface water COC
- Potassium
  - Key indicator of FMC source areas

FMC Source Areas

- Pond 8S (RU 22a)
- Old “Phossy” Ponds (RU 22b)
- Furnace Building, Phos Dock and Secondary Condenser (RU1) and Slag Pit (RU2)
- Former Kiln Scrubber Ponds and Calciners (RU 8) and Former Kiln Scrubber Overflow Pond (RU 9)
- Former Unlined Calciner Ponds and Calciner Sediment Storage Area ‘A’ (RU 14)
- Calciner Storage Area (RU 16)

Transport Modeling Process

- Initial estimates of transport parameter values
- Calibration (plume matching) to improve parameter estimates
- Predictive simulations
  - Initial conditions (observed 2008 contaminant distribution)
  - Remedial alternative simulations

Transport Model Calibration

Plume Matching

- Efforts will be made to match the current contaminant distribution
- Steady-state flow model will be used
- Measured contaminant time series will be compared to simulated
- Transport parameters for predictive simulations will be estimated

Predictive Simulations of Alternatives

Alternative 1

- Source Controls (i.e., Soil Remedial Actions)
- Institutional Controls (Prevent use/ingestion of site-impacted groundwater)
- Long-term groundwater monitoring

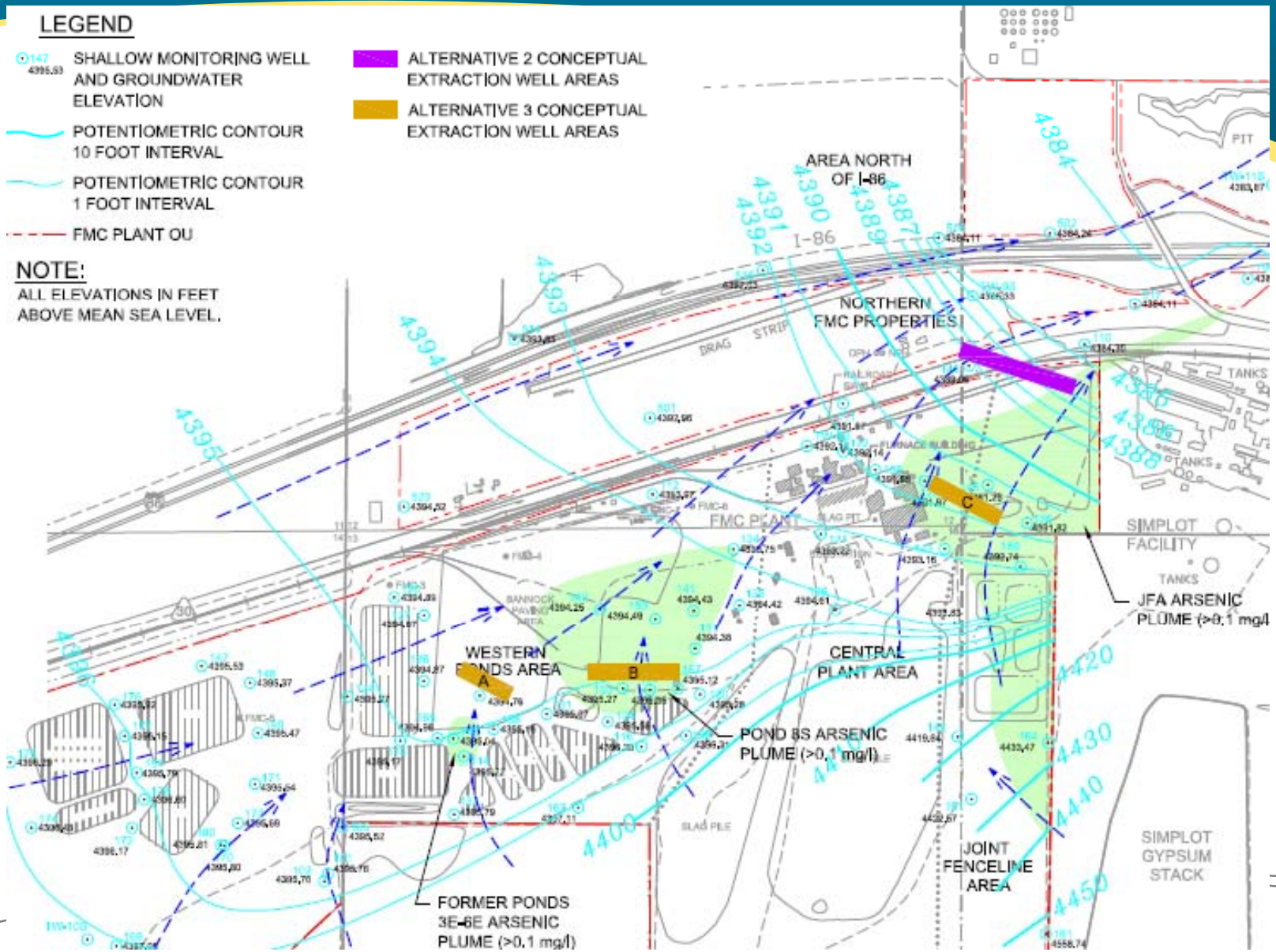
Alternative 2

- Alternative 1 components
- Groundwater extraction for hydraulic containment at plant boundary
- Treatment and/or use of extracted groundwater

Alternative 3

- Alternative 1 components
- Groundwater extraction at identified source areas
- Treatment and/or use of extracted groundwater

Predictive Simulations of Alternatives



Path Forward

- Complete flow model sensitivity analysis
- Construct and calibrate transport model
- Preliminary predictive simulations
- Meeting August 5th, 6th, or 7th
- Final predictive simulations
- Model report will be appendix to SFS report

Rob Hartman

From: Rob Hartman
Sent: Tuesday, July 07, 2009 9:07 AM
To: Kira Lynch; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; 'Fisher.Carla@epa.gov'; 'Ross.randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: Barbara Ritchie; Marc Bowman; Doug Oliver; Zachary Brown
Subject: FMC Groundwater Flow Model Meeting Follow-up
Attachments: FMC 2009 GW model - FMC & Simplot wells - layer elevs.pdf; EMF RI Table 3.3-1 Hydraulic Conductivities.pdf

During the FMC groundwater flow model review meeting on July 1, 2009, we captured the following list of action items:

1) MWH will send (or post to an ftp site) the MODFLOW files for the flow model. These will be exported from GMS as standard MODFLOW files following completion of the flow model calibration.

2) MWH will prepare .pdf files depicting hydraulic conductivity for each layer and send these to the group following completion of the flow model calibration.

3) MWH will send a table(s) containing the well / boring log information used to construct the layers in the groundwater model to the group.

4) EPA will discuss how FMC/MWH should approach the Simplot site for future predictive simulations and will provide FMC/MWH with their guidance within the next two weeks.

The Item 3 tables containing the FMC and Simplot well / boring log information (elevations assigned to the base [or bottom] of hydrostratigraphic layers) used to construct the layers in the groundwater model are attached to this message. As I pointed out during the meeting, the tables with layer elevations were developed based on direct review of the boring logs for approximately 160 borings / wells at the site. All of the logs for the borings listed on the "FMC" table are available in appendices to the EMF RI Report (RI borings) or Groundwater Current Conditions Report (post-RI borings and 'TW-series'). Many of the Simplot boring logs are available in the EMF RI appendices and the remainder were obtained from Simplot submittals posted on the Newfields (Simplot) project website or obtained directly from Simplot.

I have also attached a copy of Table 3.3-1 from the EMF Remedial Investigation Report that presents the hydraulic conductivities for approximately 80 wells at the site based on slug and pump tests performed during the RI. This table was also included in the Groundwater Current Conditions Report and is attached primarily for Randall and Milovan's benefit in reviewing the information that will be provided per Item 2 above.

As we discussed during the meeting, MWH will complete the flow model calibration and then forward Items 1 and 2 later this week or early next week. We also plan to circulate meeting minutes later this week or early next week.

Bernie / Randall: Hopefully you can confirm August 6th for the transport model / preliminary predictive simulation meeting in Pocatello this week so all on the route list can lock in that date. We also look forward to your guidance on Item 4 later this week or next. Contact me should you have questions regarding this information. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com

FMC Well Boring Logs Utilized to Assign Model Layer Elevations for the FMC Groundwater Flow Model 2009

Location	Easting	Northing	"Top of Casing" Measuring Point Elevation *	Ground surface Elevation*	Top of Screen Elevation*	Bottom of Screen Elevation*	Well Bottom Elevation*
101	551859.2	448838.9	4472.00	4470.10	4383.10	4373.10	4370.60
102	551848.4	448821.4	4471.68	4469.70	4333.20	4323.70	4321.10
103	554265.5	450122.5	4486.35	4484.70	4306.30	4286.20	4283.70
104	554270.2	450145.9	4486.71	4484.60	4388.10	4378.10	4375.60
106	556230.9	451116.9	4498.45	4496.50	4371.50	4361.50	4359.00
107	556591.1	452320.6	4482.46	4480.70	4294.50	4274.50	4272.00
108	556573.7	452316.5	4482.40	4480.30	4382.70	4372.70	4370.20
109	558357.7	453396.2	4451.31	4449.70	4312.20	4302.70	4300.10
111	556296.9	452890.2	4468.04	4466.30	4374.00	4364.60	4361.80
112	554655.3	452105.6	4467.91	4466.00	4378.20	4368.80	4366.00
113	552482.1	449982.1	4467.93	4461.20	4379.00	4369.50	4366.70
114	553029.9	449848.7	4470.60	4468.60	4351.90	4342.40	4339.60
115	552938.2	449999.6	4469.73	4467.70	4349.20	4339.20	4336.70
116	554560	449931.2	4489.23	4487.10	4380.50	4371.00	4368.50
117	555076.8	450602.4	**Abandoned**			**Abandoned**	
120	555064.5	450379.6	4500.32	4498.30	4379.60	4370.10	4367.30
121	556105.7	451766.8	4485.58	4483.50	4377.50	4367.50	4365.00
122	556282.4	452470.2	4475.92	4473.90	4372.40	4362.40	4360.90
123	557000.1	452221.3	4484.12	4482.00	4375.50	4366.00	4363.50
124	552028.7	450362.3	4448.45	4446.60	4374.00	4364.50	4361.80
125	552415.5	451221	4455.77	4454.00	4308.60	4303.60	4301.00
126	552429.6	451222.6	4455.97	4454.00	4378.50	4368.50	4366.00
127	552687.2	451067.8	4458.20	4456.40	4379.40	4369.90	4367.10
128	552683.9	450494	4461.85	4460.00	4375.70	4366.20	4363.50
130	552950.5	449329.3	4470.58	4468.50	4302.00	4292.00	4289.50
131	553742.7	450212	4485.95	4484.50	4330.60	4320.60	4318.90
133	555371.4	451641.8	4479.50	4477.20	4259.70	4239.70	4237.20
134	555354.2	451636.8	4478.93	4477.00	4374.50	4365.00	4362.20
135	555405.7	451154.5	4489.14	4487.10	4379.70	4370.30	4367.50
136	557882.9	451860.7	4479.55	4477.60	4365.10	4355.10	4352.60
137	552945.9	449345.5	4471.13	4468.40	4381.90	4371.90	4369.40
139	553167	450368.1	4467.66	4466.30	4377.90	4373.70	4370.30
140	554203.3	451119.7	4475.67	4474.20	4378.60	4369.60	4365.10
141	555009	451106.5	4493.89	4492.50	4375.60	4366.60	4363.10
142	557284.5	450017	4564.47	4563.30	4363.10	4344.90	4339.40
143	557172.8	451639	4496.31	4495.00	4382.80	4378.60	4375.20
144	557545.2	452188.1	4478.45	4477.10	4288.10	4258.10	4255.60
145	557552.3	452188.7	4478.26	4477.00	4347.00	4337.00	4334.50
146	557382.2	453214.1	4459.30	4457.90	4367.90	4352.90	4350.40
147	550769.3	450622.8	4443.69	4442.30	4371.60	4362.60	4359.10
148	551187.8	450479.4	4446.45	4445.00	4377.90	4368.90	4365.40
149	551254.4	450047.3	4447.25	4446.30	4377.00	4368.00	4364.50
151	555023.3	450773.5	4501.42	4499.90	4374.90	4364.90	4362.40
153	550476	450030.3	**Abandoned**			**Abandoned**	
154	550197.8	449702	4447.05	4445.30	4371.70	4367.50	4364.20
155	554398.54	450432.74	4491.21	4489.00	4378.80	4368.80	4366.30
156	554633.24	450418.57	4494.57	4492.10	4381.10	4371.10	4368.10
157	554874.47	450429.51	4502.30	4500.20	4379.20	4369.20	4366.70
158	554944.7	450027.9	4496.36	4494.00	4358.20	4348.20	4345.20
159	554680.1	451036	4491.79	4490.00	4381.30	4371.30	4368.30
161	558045.5	448320.6	4668.41	4666.00	4482.00	4472.00	4471.50
164	558064.3	449964.9	4588.09	4585.70	4335.70	4325.70	4325.20
165	551986.16	449237.25	4464.16	4461.70	4376.70	4366.70	4364.70
166	552801.98	450004.01	4469.77	4467.80	4382.30	4372.30	4369.80
167	554015.51	449404.11	4492.17	4490.10	4373.60	4353.60	4351.10
169	550035.76	448217.19	4474.40	4471.90	4360.90	4355.90	4355.40
170	550967.58	449078	4452.40	4450.10	4386.60	4381.60	4381.10

FMC Well Boring Logs Utilized to Assign Model Layer Elevations for the FMC Groundwater Flow Model 2009

Location	Easting	Northing	"Top of Casing" Measuring Point Elevation *	Ground surface Elevation*	Top of Screen Elevation*	Bottom of Screen Elevation*	Well Bottom Elevation*
171	551237.2	449596.49	4452.41	4449.90	4373.40	4363.40	4360.90
172	551080.8	449271.6	4450.57	4447.90	4376.90	4371.90	4368.90
173	550171.8	449231.3	4452.76	4449.80	4379.80	4364.80	4361.90
174	549303.4	449232.7	4447.12	4444.10	4369.10	4359.10	4356.20
175	549119	449797.1	4443.59	4440.60	4368.60	4358.60	4355.70
176	550019	450291.6	4443.29	4440.30	4365.50	4355.50	4352.90
177	550166.4	450022.2	4444.95	4442.00	4366.90	4356.90	4354.00
178	550275.2	449473.9	4451.14	4448.50	4388.50	4373.50	4370.70
180	550976.2	449088.4	4452.77	4450.10	4397.90	4387.90	4384.90
183	554927.8	450017.7	4497.33	4494.30	4394.30	4379.30	4376.50
189	557824	451486	4560.72	4558.70	4380.70	4371.20	4371.20
190	557256	451000.4	4541.56	4539.80	4316.80	4307.30	4306.80
191	557404.48	449477.26	4577.07	4577.10	4402.10	4392.60	4392.10
500	554642.4	452777.8	4460.60	4458.80	4323.60	4313.60	4310.80
501	554633	452767.7	4460.50	4458.80	4376.50	4366.90	4363.90
502	558079.5	454363.3	4441.30	4439.30	4375.10	4370.10	4367.30
503	560800.8	454363.7	4400.25	4397.50	4357.60	4348.00	4345.00
504	561213.1	454050.5	4394.99	4393.10	4239.30	4229.70	4226.70
505	561200.5	454047.2	4395.71	4393.80	4363.50	4353.90	4350.90
506	563065.1	452702.9	4402.43	4400.60	4323.40	4303.40	4300.60
507	563053.6	452708.1	4402.48	4400.50	4375.50	4365.50	4362.70
508	562013.5	453530.3	4392.88	4390.50	4291.80	4281.80	4279.00
509	562002.4	453533.2	4392.30	4390.30	4321.10	4311.10	4308.30
510	563771.1	452162.5	4397.70	4397.70	4298.40	4288.40	4285.60
511	563780.1	452153.4	4399.70	4397.70	4337.70	4327.70	4324.90
512	564477.8	454115.9	4414.64	4412.20	4340.50	4330.90	4327.90
513	564488.8	454115.9	4414.91	4412.40	4387.10	4377.10	4374.30
514	553463.5	453442.7	4451.90	4452.30	4371.10	4361.10	4358.80
515	555307.3	454045.1	4450.35	4450.30	4379.10	4369.10	4366.10
516	557119.4	454322.8	4445.50	4445.70	4375.20	4365.20	4362.20
517	558812.8	453747	4444.45	4442.50	4377.10	4367.10	4364.10
518	560470.7	453790	4417.15	4414.70	4374.40	4364.40	4361.40
519	560778.2	454358	4399.54	4397.50	4312.20	4292.20	4289.20
520	563607.5	452227.5	4398.80	4396.60	4370.40	4360.40	4357.40
521	552515.9	451926.4	4452.80	4450.70	4303.20	4293.20	4292.70
522	552508.4	451927.7	4453.06	4450.80	4375.80	4365.80	4365.30
523	552513.7	452001.4	4452.98	4450.80	4375.80	4365.80	4365.30
524	560768	455307	4399.92	4397.40	4348.90	4338.90	4338.40
525	560772.1	455296.9	4399.61	4397.10	4379.30	4369.30	4368.80
TW-11I	559985	454775	Not Available	4425.00	4299.00	4290.00	4290.00
TW-12S	559785	453975	4436.28	4435.00	4381.00	4373.00	4373.00
TW-2D	555085	452125	Not Available	4470.00	4178.00	4158.00	4158.00
TW-3D	551335	449975	Not Available	4445.00	4208.00	4188.00	4188.00
TW-4D	553385	451725	Not Available	4455.00	4298.00	4255.00	4255.00
TW-5D	555985	452525	4475.00	4474.00	4202.00	4191.00	4191.00
TW-9S	557413.1	453819.7	4450.23	4449.00	4373.00	4369.00	4369.00

* - Elevations are in Feet Above Mean Sea Level

Hydrogeological Regime:
B = Bannock
M = Michaud
P = Portneuf

FMC Well Boring Logs Utilized to Assign Model Layer Elevations for the FMC Groundwater Flow Model 2009

Location	Borehole Total Depth Elevation*	Shallow / Deep Well	Hydro-Geological Regime	Base Layer 1 Elev	Base Layer 2 Elev	Base Layer 3 Elev	Top of Bedrock Elev
101	4368.60	S	B	4383.10	4370.10		
102	4319.70	D	B	4384.70	4369.70	4344.70	4319.70
103	4279.70	D	M	4397.70	4369.70	4328.70	
104	4374.60	S	M	4395.60			
106	4359.00	S	B	4404.50	4386.50		4361.50
107	4271.70	D	M	4386.70		4321.70	4273.70
108	4330.30	S	M	4387.30	4350.30		
109	4298.70	D	M		4354.70	4341.70	4298.70
111	4356.30	S	M	4384.30	4359.30		
112	4366.00	S	M	4379.00	4369.00		
113	4364.20	S	M	4379.20			
114	4327.10	S	M	4397.60	4378.60	4358.60	
115	4327.70	S	M	4389.70	4382.70	4357.70	
116	4367.10	S	M	4382.10	4371.10		
117		D	M	4378.90	4353.90	4293.90	4252.90
120	4364.30	S	M	4384.30	4368.30		
121	4363.50	S	M	4388.50			
122	4352.40	S	M	4381.90	4359.90		
123	4360.80	S	M	4385.00			4364.00
124	4361.60	S	M	4378.60	4364.60		
125	4300.00	D	M	4381.00	4361.00	4332.00	4300.00
126	4364.00	S	M	4382.00	4366.00		
127	4365.90	S	M	4381.40	4368.40		
128	4363.00	S	M	4382.00	4366.00		
130	4288.50	D	M	4373.50	4368.50	4322.50	4289.50
131	4317.50	S	M	4384.50	4364.50	4334.50	
133	4227.20	D	M	4382.20	4362.20	4331.20	
134	4361.00	S	M	4382.00	4364.00		
135	4363.60	S	M	4385.10	4367.10		
136	4350.60	S	B	4365.60			4365.60
137	4368.40	S	M	4375.40			
139	4303.30	S	M	4380.30	4371.30	4336.30	4323.30
140	4314.20	S	M	4381.20	4367.20	4332.20	4322.20
141	4363.00	S	M	4385.50	4364.50		
142	4339.30	S	B	4482.30			4482.30
143	4373.00	S	B	4374.00			4374.00
144	4255.10	D	M	4389.10	4357.10	4345.10	4322.10
145	4327.00	S	M	4389.00	4361.00	4348.00	
146	4349.40	S	M	4386.90	4352.90		
147	4358.80	S	M	4375.30	4362.30		
148	4365.00	S	M	4378.00	4368.00		
149	4357.80	S	M	4381.30	4361.30		
151	4361.90	S	M	4374.90	4363.90		
153		S	M	4376.50	4365.50		4343.50
154	4362.30	S	M	4373.30	4366.30		
155	4365.40	S	M	4382.00			
156	4368.00	S	M	4383.10			
157	4365.70	S	M	4386.70			
158	4345.00	S	B	4380.00			
159	4364.00	S	M	4385.00	4366.00		
161	4457.00	S	B	4564.00			4564.00
164	4324.70	S	B	4429.70			4429.70
165	4364.50	S	M	4378.70			
166	4368.80	S	M	4383.40			
167	4351.10	S	M	4281.80	4368.00		
169	4354.90	S	M	4375.00			4354.90
170	4381.10	S	B	4391.10			4391.10

Location	Borehole Total Depth Elevation*	Shallow / Deep Well	Hydro-Geological Regime	Base Layer 1 Elev	Base Layer 2 Elev	Base Layer 3 Elev	Top of Bedrock Elev
171	4360.90	S	M	4379.90			
172	4368.40	S	B	4377.90			4369.40
173	4360.80	S	B	4374.80			4364.80
174	4356.10	S	M	4369.10			
175	4355.60	S	M	4368.60			
176	4352.30	S	M	4368.30			
177	4353.60	S	M	4372.00			
178	4370.00	S	M	4375.50			
180	4384.60	S	B	4388.10			4388.10
183	4374.60	S	B	4386.30			
189	4370.70	S	B	4385.70			
190	4304.80	S	B	4426.80			4426.80
191	4390.10	S	B	4526.10			4526.10
500	4266.80	D	M	4370.80	4346.80	4326.80	
501	4353.80	S	M	4372.80			
502	4365.30	S	P	4379.30	4368.30		
503	4341.50	S	P	4380.50	4349.50		
504	4220.10	D	P	4383.10	4345.10	4323.10	
505	4348.80	S	P	4383.80	4351.80		
506	4295.60	D	P	4384.60			
507	4360.50	S	P	4384.50			
508	4268.50	D	P	4383.50			
509	4308.30	S	P	4381.30			
510	4285.50	D	P	4375.00			
511	4324.90	S	P	4375.00			
512	4323.20	D	P	4400.20	4374.00	4349.20	
513	4372.40	S	P	4400.40	4375.90		
514	4358.30	S	M	4374.30	4362.30		
515	4364.30	S	M	4383.30			
516	4360.70	S	M	4379.70	4363.70		
517	4363.00	S	P	4380.00			
518	4360.70	S	P	4380.00			
519	4288.50	D	P	4372.50			4292.50
520	4356.60	S	P	4374.60			
521	4226.70	D	M	4381.70	4354.70	4310.70	4227.70
522	4364.30	S	M	4380.80			
523	4360.80	S	M	4382.80	4361.80		
524	4275.40	D	P	4375.00	4350.00	4335.00	4277.40
525	4368.60	S	P	4375.00			
TW-11I	4290.00	I	P	4375.00			4307.00
TW-12S	4373.00	S	P	4370.00			
TW-2D	4158.00	D	M	4372.00	4340.00	4328.00	4242.00
TW-3D	4188.00	D	M	4371.00	4354.00	4340.00	4260.00
TW-4D	4255.00	D	M	4377.00	4367.00	4353.00	4336.00
TW-5D	4191.00	D	M	4374.00	4364.00	4325.00	4216.00
TW-9S	4269.00	S	M	4397.00			4397.00

* - Elevatio

Hydrogeolog
B = Bannock
M = Michau
P = Portneuf

Simplot Well Boring Logs Utilized to Assign Model Layer Elevations for the FMC Groundwater Flow Model 2009

Station	Site	X_Coord	Y_Coord	HydroGeoArea	WaterZone	Status	Top Riser Casing Elev	Ground Surface Elev
300	Simplot	561444.9	450571.9	Bannock Range	Shallow	Abandoned	4582.23	4580.10
301	Simplot	558098	446467.8	Bannock Range	Shallow	Active	4735.73	4733.30
304	Simplot	558096	448442.4	Bannock Range	Shallow	Active	4662.42	4660.40
305	Simplot	562731.3	450749	Bannock Range	Deep	Active	4566.47	4564.20
306	Simplot	560626.1	450925.4	Bannock Range	Shallow	Abandoned	4567.98	4565.60
307	Simplot	558139.1	450908.7	Bannock Range	Shallow	Active	4561.83	4559.60
308	Simplot	558146.5	451429.3	Bannock Range	Shallow	Active	4541.49	4539.70
309	Simplot	558579.3	452286	Michaud Flats	Deep	Active	4458.14	4456.40
310	Simplot	558585.5	452273.9	Michaud Flats	Shallow	Active	4458.64	4456.60
311	Simplot	558570.8	453136	Michaud Flats	Deep	Abandoned	4451.82	4449.70
312	Simplot	558569.5	453120	Michaud Flats	Shallow	Active	4451.13	4449.80
313	Simplot	559738.1	452109.3	Bannock Range	Deep	Active	4462.86	4461.10
315	Simplot	560655.8	452006.8	Portneuf	Deep	Active	4462.73	4460.90
316	Simplot	560642.9	452012.6	Portneuf	Shallow	Active	4462.91	4460.60
317	Simplot	561401.4	452829.8	Portneuf	Deep	Active	4445.62	4438.80
318	Simplot	561410.5	452818.5	Portneuf	Shallow	Active	4448.99	4446.20
319	Simplot	559843.4	453490.4	Portneuf	Deep	Active	4441.77	4439.50
320	Simplot	559829.5	453494.6	Portneuf	Shallow	Active	4441.71	4439.60
321	Simplot	562914.8	452335.6	Portneuf	Deep	Active	4416.37	4414.40
322	Simplot	562871.3	452353.8	Portneuf	Deep	Active	4415.08	4413.70
323	Simplot	559078.5	451469.9	Bannock Range	Shallow	Active	4559.14	4555.90
324	Simplot	558564	452771	Michaud Flats	Shallow	Active	4455.13	4452.60
325	Simplot	559294.4	452735	Michaud Flats	Shallow	Active	4451.83	4449.10
326	Simplot	560648.8	452523	Portneuf	Deep	Active	4452.23	4449.10
327	Simplot	560793.9	453211.8	Portneuf	Shallow	Active	4433.29	4432.90
328	Simplot	562236.8	452717.3	Portneuf	Shallow	Active	4414.35	4411.70
329	Simplot	558571.4	453107	Michaud Flats	Deep	Active	4451.94	4449.50
330	Simplot	559129.1	453485.1	Michaud Flats	Deep	Active	4445.34	4443.50
331	Simplot	559113.8	453486.4	Michaud Flats	Shallow	Active	4445.6	4443.50
332	Simplot	561497	452470	Portneuf	Shallow	Active	4451.17	4448.80
333	Simplot	558107.3	450061.2	Bannock Range	Shallow	Active	4579.54	4577.20
334	Simplot	560087	452772	Michaud Flats	Shallow	Active	4446.98	4447.10
336	Simplot	558230.3	451151.1	Bannock Range	Shallow	Active	4556.63	4554.30
337	Simplot	560698.9	452460.6	Michaud Flats	Deep	Active	4455.33	4453.10
343	Simplot	558176.9	451159.1	Bannock Range	Deep	Boring only		4553.80
344	Simplot	560745.1	452390.1	Michaud Flats	Deep	Active	4457.75	4455.50
346	Simplot	558629.5	451581.9	Bannock Range	Deep	Active	4542.93	4540.00
347	Simplot	560165.6	453326.4	Michaud Flats	Deep	Active	4439.92	4440.50
350	Simplot	561951.5	452546	Michaud Flats	Shallow	Active	4441.48	4439.80
355	Simplot	560067.2	451643.4	Bannock Range	Shallow	Active	4536.38	4534.87
361	Simplot	560445.9	452428.9	Michaud Flats	Deep	Active	4452.42	4449.10
362	Simplot	560451.9	452437.1	Michaud Flats	Shallow	Active	4451.78	4448.80
363	Simplot	561301.4	452410.7	Michaud Flats	Deep	Active	4454.08	4451.35
364	Simplot	561921.9	452413.8	Michaud Flats	Deep	Active	4450.06	4447.52
365	Simplot	561345.5	452629	Michaud Flats	Shallow	Active	4446.77	4444.36
366	Simplot	562400.1	452261.5	Michaud Flats	Deep	Active	4445.73	4443.44
367	Simplot	559654.2	453238.5	Michaud Flats	Shallow	Active	4445.38	4445.49
368	Simplot	561356.5	452855.2	Michaud Flats	Deep	Active	4443.5	4440.68
410	Simplot	560696.3	452413.3	Michaud Flats	Deep	Active	4456.43	4454.00
412	Simplot	560471.4	452458.5	Michaud Flats	Multilev	Active	4451.72	4448.70
413	Simplot	561324.4	452645.3	Michaud Flats	Multilev	Active	4447.46	4445.10
414	Simplot	560062.7	453154	Michaud Flats	Shallow	Active	4447.49	4443.94
415	Simplot	558594.1	452253	Michaud Flats	Multilev	Active	4459.06	4456.50
526	Simplot	561280.3	453229.8	Michaud Flats	Deep	Active	4429.19	4429.75
528	Simplot	560823	453396.2	Portneuf	Multilev	Active	4416.68	4413.59
529	Simplot	561066.8	453339.1	Portneuf	Deep	Active	4413.91	4411.48
335D	Simplot	560043	453065	Michaud Flats	Deep	Active	4444.82	4445.00

Station	Top of Screen Elev	Bottom of Screen Elev	Bottom of Hole Elev	Base Layer 1 Elev	Base Layer 2 Elev	Base Layer 3 Elev	Top of Bedrock Elev
300	4381.8	4362.2	4353.1	4413.10	4378.10	4368.10	
301	4563	4553.3	4494.3	4564.40	4524.30	4514.30	4514.30
304	4384.9	4370.2	4365.4	4549.40			4374.40
305	4284.2	4264.2	4258.2	4377.20			
306	4349.9	4330.3	4318.6	4424.60	4403.60	4378.60	4353.60
307	4397.6	4387.6	4383.6	4393.60			
308	4388.9	4368.9	4363.7	4393.70			
309	4308.4	4288.4	4284.4	4381.40	4359.40	4356.40	4289.40
310	4374.6	4369.6	4366.6	4380.60			
311	4319.7	4309.7	4305.7	4384.70	4363.70	4342.70	4309.70
312	4360.8	4352.1	4348.8	4382.80	4365.80		
313	4355.1	4350.1	4335.1	4339.10			4339.10
315	4340.9	4320.9	4289.9	4390.90	4374.90	4345.90	
316	4378.6	4373.6	4370.6	4393.60	4373.60		
317	4329.1	4309.1	4305.8	4375.80	4358.80	4343.80	
318	4386.2	4366.2	4362.2	4370.00	4356.90		
319	4299.5	4279.5	4268.5	4375.00	4363.50	4344.50	
320	4384.2	4369.2	4363.6	4375.00			
321	4277.5	4257.9	4251.4	4372.40	4360.00	4340.00	
322	4280.2	4270.5	4253.7	4375.70	4360.00	4340.00	
323	4384.1	4379.1	4375.9	4464.90			4464.90
324	4355.1	4350.1	4346.6	4375.00	4350.00		
325	4374.5	4369.5	4363.1	4365.00			
326	4344.1	4339.1	4333.1	4382.10	4361.10	4350.10	
327	4373.9	4363.9	4356.9	4370.00	4355.00		
328	4366.7	4356.7	4345.7	4375.00	4350.00		
329	4322	4312	4307.5	4384.50	4367.50	4341.50	4308.50
330	4297.8	4277.8	4263.5	4380.00	4358.50	4338.50	
331	4378	4368	4353.5	4380.00			
332	4382.5	4372.5	4369.5	4370.00	4371.80		
333	4418.2	4408.2	4404.7	4418.70			4405.20
334	4383.6	4373.6	4373.1	4370.00			
336	4408.2	4378.2	4373.3	4402.30			4374.30
337	4335.5	4295.5	4274.1		4387.10	4338.10	
343				4403.80			
344	4324.7	4309.7	4306.5	4393.50	4376.50	4354.50	
346	4303.8	4288.5	4283	4380.00			4287.00
347	4336.1	4316.1	4313.58		4353.50	4337.50	
350	4362.8	4358.3	4355.8		4372.80		
355	4378.37	4363.87	4334.87	4386.87			4340.87
361	4348.8488	4173.8488	4172.0988	4388.00	4352.10	4328.10	4185.60
362	4384.1709	4374.1709	4372.8009	4388.00			
363	4344.5881	4264.5881	4263.3481	4367.90	4360.35	4348.35	4300.85
364	4352.2736	4286.2736	4279.0236	4375.52	4359.52	4343.02	4311.52
365	4388.1171	4378.1171	4377.3571	4375.00			
366	4349.4448	4289.4448	4285.4448	4378.44	4358.94	4345.44	4316.44
367	4387.5397	4372.5397	4369.4897	4365.00			
368	4285.179	4245.179	4242.679		4357.68	4337.68	4265.68
410	4334	4294	4288.5	4392.00	4374.50	4359.00	4230.00
412	4391.4	4269.3	4258.9	4392.70	4376.20	4345.20	4165.20
413	4392.1	4311.1	4300.7	4367.10	4362.10	4347.10	4271.10
414	4383.4423	4373.4423	4361.9423	4365.00	4373.94	4340.00	
415	4383.6	4310.7	4300.4	4378.50	4362.50	4345.00	4305.50
526	4325.17	4305.17	4302.65		4338.75	4335.75	
528	4353.3927	4218.3927	4197.5927	4365.00	4350.00	4357.59	
529	4387.0787	4292.0787	4285.4787	4365.00	4350.00	4343.48	
335D	4343	4333	4331	4365.00	4362.00	4347.00	

TABLE 3.3-1

HYDRAULIC CONDUCTIVITIES AND TRANSMISSIVITIES OF EMF AQUIFER SYSTEM

TABLE 3.3-1

	Shallow Wells	Hydraulic Conductivity cm/s	Hydraulic Conductivity ft/day	Type of Test	Source
MICHAUD FLATS	104	4.45E-02	126	Slug Test	BEI
	108	1.01E-01	286	Slug Test	BEI
	110	3.80E-02	108	Slug Test	BEI
	111	1.40E-01	397	Slug Test	BEI
	113	1.40E-01	397	Pumping Test	BEI
	126	5.85E-02	166	Slug Test	BEI
	134	1.09E-01	309	Slug Test	BEI
	135	3.15E-02	89.3	Slug Test	BEI
	139	1.90E-02	53.9	Slug Test	BEI
	140	9.70E-02	275	Slug Test	BEI
	146	6.10E-02	173	Slug Test	Hydrometrics
	148	2.45E-02	69.5	Slug Test	Hydrometrics
	150	3.55E-01	1000	Pumping Test	BEI
	153	3.30E-01	935	Slug Test	BEI
	154	1.74E-02	49.3	Slug Test	Hydrometrics
	501	9.05E-02	257	Slug Test	BEI
	514	3.92E-02	111	Slug Test	Hydrometrics
	515	1.05E-02	29.8	Slug Test	Hydrometrics
	516	2.33E-02	66.0	Slug Test	Hydrometrics
BANNOCK RANGE	106	4.30E-03	12.2	Slug Test	Hydrometrics
	142	7.00E-04	1.98	Slug Test	BEI
	300	2.43E-04	0.69	Slug Test	Hydrometrics
	301	1.00E-05	0.03	Slug Test	BEI
	304	4.95E-04	1.41	Slug Test	Hydrometrics
	306	1.17E-03	3.32	Slug Test	Hydrometrics
	307	9.91E-02	281	Slug Test	Hydrometrics
	308	2.51E-02	71.2	Slug Test	Hydrometrics
	313	1.80E-02	51.0	Slug Test	BEI
	316	1.02E-02	28.9	Slug Test	BEI
	323	1.20E-03	3.40	Slug Test	Hydrometrics
	325	5.45E-03	15.5	Slug Test	BEI
	333	9.91E-03	28.1	Slug Test	Hydrometrics
	PEI-2	1.00E-03	2.83	Pumping Test	PEI
	PEI-5	4.50E-04	1.28	Pumping Test	PEI
PORTNEUF RIVER	312	1.40E+00	3970	Pumping Test	BEI
	318	1.40E-03	3.97	Slug Test	BEI
	324	5.45E-02	154	Slug Test	BEI
	327	1.18E-01	334	Slug Test	Hydrometrics
	328	1.84E-01	522	Slug Test	Hydrometrics
	502	1.39E-01	394	Slug Test	Hydrometrics
	503	1.68E+00	4760	Slug Test	BEI
	505	3.66E-01	1038	Slug Test	Hydrometrics
	507	6.40E-01	1810	Slug Test	BEI
	517	7.20E-01	2040	Slug Test	BEI
	518	1.49E-01	422	Slug Test	Hydrometrics

	Deep Wells	Hydraulic Conductivity cm/s	Hydraulic Conductivity ft/day	Type of Test	Source
MICHAUD FLATS	103	5.20E-03	14.7	Slug Test	BEI
	107	2.20E-02	62.4	Slug Test	BEI
	109	5.15E-03	14.6	Slug Test	BEI
	125	7.22E-02	205	Slug Test	Hydrometrics
	133	1.20E-01	340	Slug Test	BEI
	145	2.15E-01	609	Slug Test	BEI
	500	6.70E-02	190	Slug Test	BEI
BANNOCK RANGE	315	1.19E-02	33.7	Slug Test	BEI
PORTNEUF RIVER	311	8.60E-04	2.44	Slug Test	BEI
	317	9.90E-03	28.1	Slug Test	BEI
	319	1.00E-02	28.4	Slug Test	BEI
	321	1.50E-01	425	Slug Test	BEI
	322	2.80E-01	794.7	Pumping Test	BEI
	329	3.65E-01	1030	Slug Test	BEI
	330	5.64E-02	160	Slug Test	Hydrometrics
	504	7.10E-02	201	Slug Test	Hydrometrics
	506	2.30E-01	652	Slug Test	BEI
	512	5.80E-01	1640	Slug Test	BEI
	519	1.59E-02	45.0	Slug Test	Hydrometrics

	Production Wells	Transmissivity (ft^2/day)	Transmissivity (gpd/ft)	Type of Test	Source
MICHAUD FLATS	FMC-6	7370	55130	Pumping Test	BEI
	32ACD1	35100	262550	Pumping Test	USGS
	32DDC1	135700	1015000	Pumping Test	USGS
	33BAA1	21900	163810	Pumping Test	USGS
	33CCD1	41400	309670	Pumping Test	USGS
	34ADD1	40400	302190	Pumping Test	USGS
	34DCC1	36600	273770	Pumping Test	USGS
	35DDC1	164400	1229700	Pumping Test	USGS
	3ACD1	41200	308176	Pumping Test	USGS
	3BDC1	444000	3321100	Pumping Test	USGS
	4BBA1	38500	287980	Pumping Test	USGS
	5BDA1	36800	275260	Pumping Test	USGS
	8ADA1	27300	204200	Pumping Test	USGS
	9CAC1	199000	1488500	Pumping Test	USGS
	12BBC1	54700	409160	Pumping Test	USGS
PORTNEUF RIVER	SWP-7	227270	1700000	Pumping Test	Simplot

References:
BEI = Bechtel Environmental, Inc., Preliminary Site Characterization Summary for the Eastern Michaud Flats site, January, 1994
PEI = PEI Associates, Inc., Evaluation of Waste Management for Phosphate Processing, April 1985
Hydrometrics = Hydrometrics, Inc., Hydraulic Conductivity Testing of Existing Well Sites at the Eastern Michaud Flats Site, Pocatello, Idaho, April 1994
USGS = United States Geological Survey, Water-Resources Investigations Report 84-4201, Hydrogeology of Eastern Michaud Flats, Fort Hall Indian Reservation, Idaho
Simplot = J.R. Simplot files
FMC = FMC files

Hydraulic conductivity at Well 318 not used in K-zone mapping due to potential precipitation reactions in formation related to mixing of low pH water with groundwater.
Transmissivity at Well 311 not used due to possible grout contamination in filter pack.

Rob Hartman

From: Zavala.Bernie@epamail.epa.gov
Sent: Wednesday, July 08, 2009 4:29 PM
To: Rob Hartman
Cc: Barbara Ritchie; Zavala.Bernie@epamail.epa.gov; Douglas Oliver Jr.; Doug Tanner; Lynch.Kira@epamail.epa.gov; Kelly Wright; Marc Bowman; mbeljin@cinci.rr.com; Ross.Randall@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Susan Hansen; Zachary Brown; ctanaka@shoshonebannocktribes.com; bcotton@newfields.com; monty.johnson@simplot.com
Subject: Re: FMC Groundwater Flow Model Meeting Follow-up
Attachments: flowmodel709fmc.doc; FMC 2009 GW model - FMC & Simplot wells - layer elevs.pdf; EMF RI Table 3.3-1 Hydraulic Conductivities.pdf

Rob,

Thanks for the follow-up from our meeting on July 1st re: the FMC Groundwater Flow Model meeting.

To All:

Attached is a brief summary of the July 1st meeting including an attempt to address the action item that was requested by FMC. Also, if anyone would like to add to this brief summary, feel free to do so and reply to all. EPA is still working on confirming the August 6th date or offering another date for the transport model/preliminary predictive simulation meeting in Pocatello.

Bernie

(See attached file: flowmodel709fmc.doc)

****
Bernie Zavala, Hydrogeologist
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Zavala.Bernie@EPA.GOV
****

Rob Hartman
<Rob.J.Hartman@us.mwhglobal.com>

07/07/2009 08:06 AM

To
Kira Lynch/R10/USEPA/US@EPA, Bernie Zavala/R10/USEPA/US@EPA, "Scott.Miller@deq.idaho.gov" <Scott.Miller@deq.idaho.gov>, Doug Tanner <Douglas.Tanner@deq.idaho.gov>, Kelly Wright <kwright@shoshonebannocktribes.com>, Susan Hansen <susanh@ida.net>, Carla

Fisher/R10/USEPA/US@EPA, Randall Ross/ADA/USEPA/US@EPA, "mbeljin@cinci.rr.com" <mbeljin@cinci.rr.com>

cc

Barbara Ritchie <Barbara_Ritchie@fmc.com>, Marc Bowman <Marc.E.Bowman@us.mwhglobal.com>, Douglas Oliver Jr. <Douglas.S.Oliver@us.mwhglobal.com>, Zachary Brown <Zachary.A.Brown@us.mwhglobal.com>

Subject

FMC Groundwater Flow Model Meeting Follow-up

During the FMC groundwater flow model review meeting on July 1, 2009, we captured the following list of action items:

1) MWH will send (or post to an ftp site) the MODFLOW files for the flow model. These will be exported from GMS as standard MODFLOW files following completion of the flow model calibration.

2) MWH will prepare .pdf files depicting hydraulic conductivity for each layer and send these to the group following completion of the flow model calibration.

3) MWH will send a table(s) containing the well / boring log information used to construct the layers in the groundwater model to the group.

4) EPA will discuss how FMC/MWH should approach the Simplot site for future predictive simulations and will provide FMC/MWH with their guidance within the next two weeks.

The Item 3 tables containing the FMC and Simplot well / boring log information (elevations assigned to the base [or bottom] of hydrostratigraphic layers) used to construct the layers in the groundwater model are attached to this message. As I pointed out during the meeting, the tables with layer elevations were developed based on direct review of the boring logs for approximately 160 borings / wells at the site. All of the logs for the borings listed on the "FMC" table are available in appendices to the EMF RI Report (RI borings) or Groundwater Current Conditions Report (post-RI borings and 'TW-series'). Many of the Simplot boring logs are available in the EMF RI appendices and the remainder were obtained from Simplot submittals posted on the Newfields (Simplot) project website or obtained directly from Simplot.

I have also attached a copy of Table 3.3-1 from the EMF Remedial Investigation Report that presents the hydraulic conductivities for approximately 80 wells at the site based on slug

and pump tests performed during the RI. This table was also included in the Groundwater Current Conditions Report and is attached primarily for Randall and Milovan's benefit in reviewing the information that will be provided per Item 2 above.

As we discussed during the meeting, MWH will complete the flow model calibration and then forward Items 1 and 2 later this week or early next week. We also plan to circulate meeting minutes later this week or early next week.

Bernie / Randall: Hopefully you can confirm August 6th for the transport model / preliminary predictive simulation meeting in Pocatello this week so all on the route list can lock in that date. We also look forward to your guidance on Item 4 later this week or next. Contact me should you have questions regarding this information. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com(See attached file: FMC 2009 GW model - FMC & Simplot wells - layer elevs.pdf)(See attached file: EMF RI Table 3.3-1 Hydraulic Conductivities.pdf)

Kick-Off meeting for the Groundwater model regarding the EMF Superfund site, FMC OU, 7/1/2009

The following is a brief summary of the meeting re: GW Flow modeling for the former FMC plant in Pocatello, Idaho for the Supplemental Feasibility Study.

Barbara Ritchie, FMC opened the meeting by stating the objective for the flow and transport groundwater model. She stated that these modeling efforts will be used as a tool for comparison of remedial alternatives in the Supplemental Feasibility Study (SFS) for the FMC operable unit.

Two presentations were given by MWH, the first by Rob Hartman who summarized the site geology, hydrogeology and discharge (cfs) of the Portneuf River. This presentation also included the nature and extent of the site contamination for the FMC source areas within the model domain. Simplot sources were also noted in the presentation. Rob emphasis that the hydrogeology is relatively complex but the groundwater system or hydraulics has been stable over the 18 years of groundwater data collection. Rob also identified the locations of significant phosphorus and arsenic sources at the EMF Superfund site, they were the Simplot gypsum stack, Phosphoric Acid Plant (PAP), FMC former Pond 8S and the E-ponds under and around pond 15S.

The second presentation was lead by Zac Brown who summarized the approach that FMC will take regarding the groundwater flow and transport modeling. The models that will be used are MODFLOW, MODPATH and MT3DMS. Zac covered the model domain, layering (4-layers), hydraulic conductivity distribution and boundary conditions. MWH has performed a simulation of the water levels and compared it to 2008 average observed water level contours. MWH feels that the flow model is adequately calibrated but needs additional sensitivity analysis that will be conducted and presented in the SFS report.

Doug Oliver, MWH continued the modeling discussion and gave an overview of the contaminant transport model plan. The following is the purpose and objectives of the modeling:

- *To simulate transport of the primary contaminant and indicator parameters*
- *Support the SFS and remedial alternatives development*
- *To evaluate and optimize remedial alternatives*

The primary contaminants are Arsenic and Total Phosphorus and indicator parameter is Potassium. Doug listed six FMC source areas that will be modeled. Plume matching will be the approach MWH will use for model calibration for parameter estimates.

FMC/MWH listed the three groundwater alternatives that will be modeled:
Alternative 1

- *Source controls (i.e., Soil Remedial Actions)*
- *Institutional Controls (Prevent use/ingestion of site-impacted groundwater)*

- *Long-term groundwater monitoring*

Alternative 2

- *Alternative 1 components*
- *Groundwater extraction for hydraulic containment at plant boundary*
- *Treatment and/or use of extraction groundwater*

Alternative 3

- *Alternative 1 components*
- *Groundwater extraction at identified source areas*
- *Treatment and/or use of extraction groundwater*

The following are questions and comments from EPA either during the meeting or were developed after the July 1st meeting.

- The groundwater flow model is moving forward at a rapid pace and EPA would like to get the MODFLOW files to gain a better understanding of the key parameters in the flow model such as the hydraulic conductivities in the four different layers and also the K's that are associated with simulated water level contours.
- The slide during Zac's presentation on hydraulic conductivity distribution for layer 2 range from 0.25 to **10,000** feet/day is that a misprint?
- It would be good to re-survey the staff gauge at the Batiste road Spring and make any necessary adjustment to the collected measurement of the river stage from the readings that have been collected since the RI.
- The predictive simulations of alternatives should add alternative 4 :
    - Alternative 1 components
    - Groundwater extraction at both the source areas and hydraulic containment at plant boundary
    - Treatment and/or use of extracted groundwater.

Any additional specific comments regarding the model (the boundary conditions, flux calibration, conductivity distribution-horizontal and vertical, and recharge value) will be provided once a site visit has been completed, review the model input data and other pertinent documents.

Action item for EPA:

FMC/MWH is requesting how EPA would like to approach the Simplot site for future predictive simulations regarding the flow components such as seepage flux from the gypsum stack, production well rate and the remediation wells extraction rates.

EPA's response to the action item:

The following information was requested by FMC/MWH as an action item:

2008 – Flux from the gypsum stack is approximately 900 gpm on average.
14-extraction wells were pumping at 804 gpm for both upper and lower zones.

3-Production wells were also pumping at 3,055 gpm (this information taken from the NewFields Groundwater Extraction System Report, 4Q 2008, 1/21/2009).

Predictive simulations- Flux reduction from liner was calculated by Simplot in the draft Technical Report No.1, April 2009 in appendix E. Simplot must achieve a 50% reduction of the contamination max flux to the Portneuf River by 2013 and then another reduction of 75% by 2015 from the baseline condition. The predictive flux of the gypsum stack can be found in Appendix E.

Production Well flow will remain unchanged at 3,055 gpm
Superfund extraction well system will be a total of 1,423 gpm; upper zone -395 gpm and the lower zone 1,028 gpm.

Action items for MWH:
EPA is requesting a map of the hydraulic conductivities (Ks) within the model domain for the different layers. The EPA would like to get the MWH ftp site to download the MODFLOW files for the flow model.

People who attended this meeting/call on July 1, 2009:

FMC	MWH
Barbara Ritchie	Rob Hartman
	Zac Brown
	Doug Oliver
	Marc Bowman

EPA
Bernie Zavala
Randall Ross (by conference phone)
Milovan Beljin (by conference phone)

IDEQ
Scott Miller
Doug Tanner

Sho Ban Tribes
Kelly Wright
Susan Hanson
Candon Tanaka

Bernie Zavala, EPA-Region 10
July 08, 2009

Rob Hartman

From: Rob Hartman
Sent: Friday, July 10, 2009 11:07 AM
To: Kira Lynch; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; Fisher.Carla@epa.gov; Ross.randall@epa.gov; mbeljin@cinci.rr.com
Cc: Barbara Ritchie; Marc Bowman; Doug Oliver; Zachary Brown
Subject: Meeting Minutes - FMC GW Flow Model Meeting July 1, 2009
Attachments: FMC GW Flow Model Meeting Minutes 1July09.pdf; flowmodel709fmc.pdf; Frontend for FMC SFS GW Model 1Jul09.pdf; FMC SFS GW Model 1Jul09.pdf

On behalf of FMC, I am routing a copy of the meeting minutes for the July 1, 2009 FMC Groundwater Flow Modeling Meeting. As indicated in the minutes, a copy of Bernie Zavala's meeting notes contained in the file "flowmodel709fmc" that was attached to his email of July 8 is included as an attachment to these meeting minutes (and to this email as a pdf file). The meeting presentations are also attached to the meeting minutes (and to this email). Thank you, Rob.

Rob J. Hartman, P.G.
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Meeting Minutes
FMC Plant OU SFS Groundwater Modeling Meeting
Idaho DEQ Offices, Pocatello, Idaho
Conducted on July 1, 2009

Attendees:

U.S. EPA:	Bernie Zavala, Randall Ross(*), Milovan Belijin(*)
Idaho DEQ:	Scott Miller, Doug Tanner
Shoshone-Bannock Tribes:	Kelly Wright, Susan Hansen, Candon Tanaka
FMC:	Barbara Ritchie
MWH:	Marc Bowman, Rob Hartman, Zak Brown, Doug Oliver

(*) via teleconference:

The objective of this meeting was to present the groundwater flow model constructed for the FMC Plant OU that will be used in the SFS alternatives evaluation and get buy-in from the group on the groundwater flow model calibration. Because the modeling is being performed on an accelerated schedule to support the SFS, this on-board review was intended to facilitate agency review and input while still holding to the overall SFS schedule.

Rob Hartman gave a presentation on the site background focusing on the hydrogeology and the nature and extent of groundwater contamination.

Zak Brown gave a presentation on the groundwater flow modeling performed to date including modeling methodology and calibration results. The flow model will be revised slightly before completion of the calibration and sensitivity analysis and then the modeling effort will proceed with the contaminant transport modeling.

Doug Oliver presented plans for the contaminant transport modeling effort and modeling of groundwater remedial alternatives.

The associated PowerPoint presentations were provided to all attendees and are attached.

Key issues and discussion topics

The following paragraphs summarize the main issues, comments, and questions that were raised during this meeting:

The group agreed that the calibration of the groundwater flow model appeared adequate; however, MWH will make some minor changes in an effort to further improve the flow model calibration prior to beginning construction of the transport model. Milovan Belijin suggested that flow budgets, particularly flow to the river and springs, should be emphasized in the flow model calibration discussion in the model report that will be provided as an appendix to the SFS Report.

Kelly Wright and Candon Tanaka pointed out that there is a diversion from the Portneuf River (Michaud diversion), just above the Tyhee gauging station at Siphon Road, where irrigation water is withdrawn. Rob Hartman agreed that there are additional inputs to the river (e.g., Pocatello POTW discharge) and withdrawals (for irrigation) between the Pocatello and Tyhee USGS gages; however, the DEQ flow measurements for the river reach between DEQ stations T-1 and T-2 do not include those inputs/withdrawals and are more appropriate for evaluating model calibration. The locations of the gauging stations will need to be considered when using flow data from the river for comparison to the model predicted discharge to the river. MWH will review USGS gauging data in more detail for use in the calibration.

A question was raised about the use of PEST in the calibration. Zak Brown explained that the model was calibrated manually, then PEST was used to improve this calibration by constraining the possible hydraulic conductivity values with specific ranges.

The EPA would like to see the hydraulic conductivity distribution (K-field) for each layer. MWH will prepare pdf files with hydraulic conductivity for each layer and send these to the group following completion of the flow model calibration. There were also questions concerning the thickness of the layers and how these were set. The layering was based on the conceptual site model and drilling logs from approximately 160 FMC and Simplot wells within the model domain.

Additional questions were raised concerning how the FMC/MWH model relates to the groundwater models constructed for Simplot by NewFields. The models constructed for Simplot were small in areal extent (generally less than 2,000 feet on a side) relative to the FMC/MWH model, which has a domain that is 15,500 feet by 9,000 feet. The FMC/MWH model is less likely to have the predictive results impacted by boundary conditions.

Arsenic, orthophosphate/total phosphorus, and potassium will be simulated in the transport model. Arsenic was selected because it is the primary risk driver in groundwater and defines the areal extent of groundwater impacts at the site. Total phosphorus was selected because of its widespread nature and due to potential impacts to surface water quality. Potassium was selected because it is a good indicator of FMC's groundwater source areas relative to those of Simplot.

Concerning the predictive simulations, MWH requested guidance from EPA concerning how to approach modeling of the Simplot site in the future predictive simulations. In particular, how should water fluxes (pumping, seepage from gyp stack) and contaminant fluxes be simulated. Bernie Zavala will try to get back to FMC/MWH next week concerning EPA's suggested approach for simulating Simplot in the future predictive runs. Although the group acknowledged that leakage from gyp stacks likely will change as the stack is capped; however, FMC/MWH requested 'simplified' assumptions to avoid complicating FMC's model with highly temporally variable assumptions for Simplot's gyp stack and extraction/production pumping.

Both the EPA and DEQ would like to see an alternative evaluated that combines the hydraulic containment wells of Groundwater Alternative 2 with the pump and treat wells of Groundwater Alternative 3. Rob Hartman responded that an "Alternative 4" would not add protectiveness as there are no receptors to groundwater between the conceptual Alternative 2 and 3 extraction areas, would not likely shorten the timeframe for achievement of the groundwater RAOs, would be highest cost and thus should be screened out from the detailed / comparative analysis for which the groundwater model is being developed. Scott Miller suggested that inclusion of an "Alternative 4" predictive simulation could be useful to document the lack of added protectiveness. FMC/MWH proposed deferring simulation of "Alternative 4" until after running simulations for Alternatives 1 – 3 and, based on those simulations, evaluating whether or not "Alternative 4" would be significantly different than Alternatives 2 and 3 in terms of remedial timeframe.

Other discussion related to plans for the future predictive simulations included how to simulate recharge for the capped areas. Areal recharge should be maintained at 1.1 inches/year (10% of annual precipitation) in areas proposed for gamma caps in the soils alternatives.

Other Items

All correspondence within the "FMC groundwater model" group should be routed through Rob Hartman of MWH.

Action Items

1. MWH will send (or post to an ftp site) the MODFLOW files for the flow model for access by agency personnel. These will be exported from GMS as standard MODFLOW files following completion of the flow model calibration.

2. MWH will prepare .pdf files with hydraulic conductivity for each layer and send these to the group following completion of the flow model calibration.

3. MWH will send a table(s) containing the well / boring log information used to construct the layers in the groundwater model to the group. Completed July 7: Rob Hartman email (Subject: "FMC Groundwater Flow Model Meeting Follow-up") and attachments ("FMC 2009 GW model – FMC & Simplot wells – layer elevs.pdf" and "EMF RI Table 3.3-1 Hydraulic Conductivities.pdf").

4. EPA will discuss how FMC/MWH should approach the Simplot site for future predictive simulations and will provide FMC/MWH with their guidance within the next two weeks. Completed July 8: Bernie Zavala email (Subject: "Re: FMC Groundwater Flow Model Meeting Follow-up") and attachment ("flowmodel709fmc.doc"). Bernie Zavala's July 1, 2009 meeting notes are summarized in "flowmodel709fmc.doc" and are attached as a companion to these meeting minutes.

Next Meeting

The next SFS Groundwater Modeling meeting is tentatively scheduled for August 5th and 6th in Pocatello. The meeting is planned for Pocatello so that Milovan and/or Randall can visit the site – tentatively on the afternoon of August 5th. This meeting will include presentation of the transport model calibration and preliminary results for the predictive simulations.

Rob Hartman

From: Rob Hartman
Sent: Wednesday, July 22, 2009 3:44 PM
To: 'Kira Lynch'; 'Zavala.Bernie@epamail.epa.gov'; 'Scott.Miller@deq.idaho.gov'; 'Doug Tanner'; 'Kelly Wright'; 'Susan Hansen'; 'Fisher.Carla@epa.gov'; 'Ross.randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: Barbara Ritchie; David M Heineck; Marc Bowman; Doug Oliver; Zachary Brown
Subject: FMC GW Flow Model Meeting Action Items 1 and 2
Attachments: FMC Flow Model - Conductivity Distribution Figures (7-20-09).pdf

Action items 1 and 2 identified in the FMC minutes for the July 1, 2009 groundwater flow model meeting are addressed below:

Action Item 1. MWH will send (or post to an ftp site) the MODFLOW files for the flow model for access by agency personnel. These will be exported from GMS as standard MODFLOW files following completion of the flow model calibration. These files have now been posted to the MWH ftp site and will remain on the ftp site for 30 days. Login information and instructions:

The ftp site link is: ftp.mwhglobal.com
Username: slc1-FMC
Password: polonium

Instructions for accessing the Ftp site with Internet Explorer 5.0 or higher:

Open Browser and go to ftp.mwhglobal.com
Go to File on your drop down menu and select “Login As” – the login menu should pop-up automatically if you have Explorer 7.0 or higher.
Enter “slc1-FMC” for the user name and “polonium” for the password. This will log you in and display the files that have been loaded onto the site. Select the folder “GW Model Files” and open.
Select the files you need, right click on one and use the "Copy To Folder" option on the popup menu to save files to your local computer (Explorer 7.0 or higher should allow ‘drag and drop’ copying to local computer).

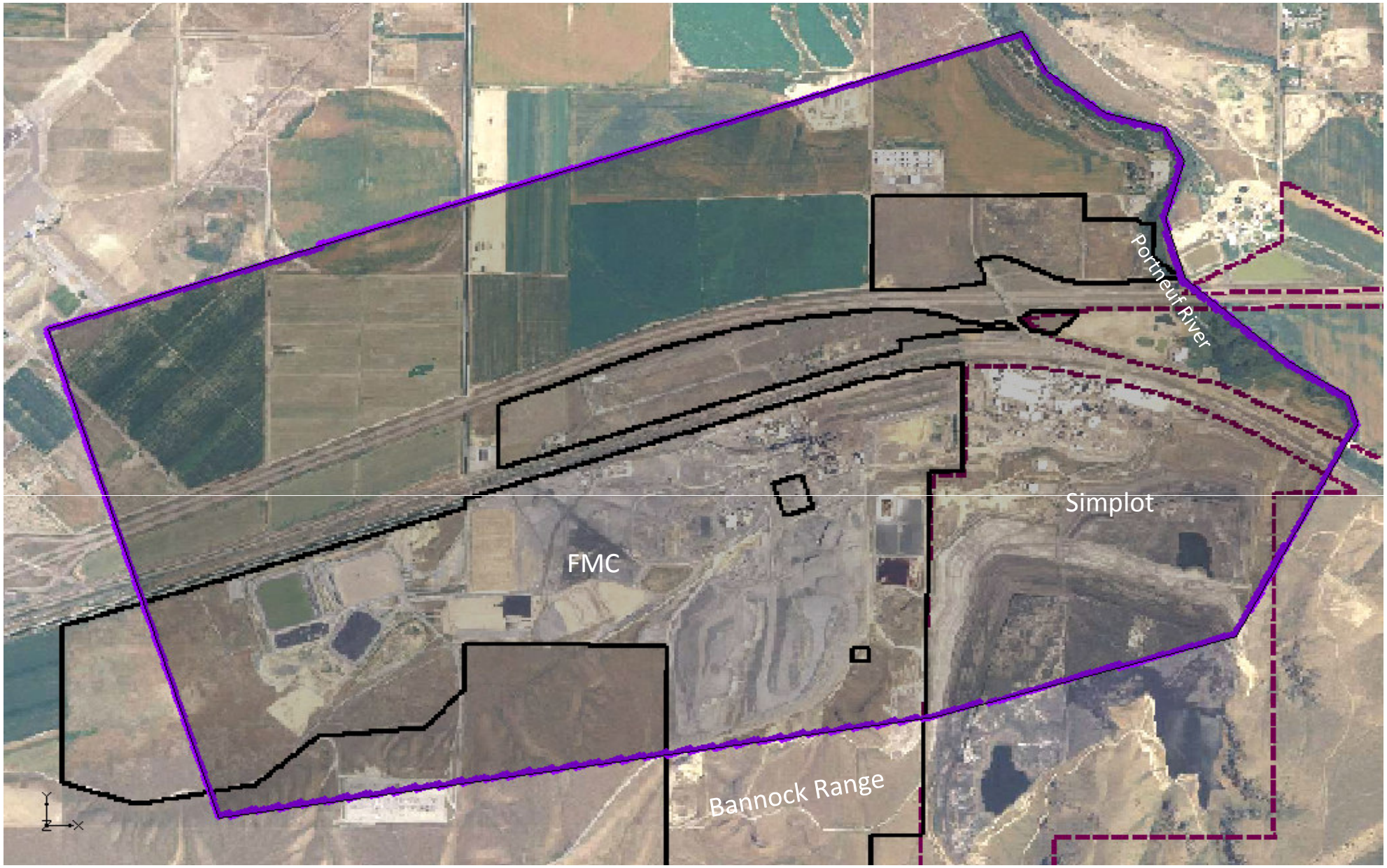
Action Item 2. MWH will prepare pdf files with hydraulic conductivity for each layer and send these to the group following completion of the flow model calibration. The attached file "FMC Flow Model - Conductivity Distribution Figures (7-20-09).pdf" contains a reference aerial photograph of the site showing the flow model domain and figures showing the hydraulic conductivity distribution for the four (4) groundwater flow model layers.

Action items 3 and 4 (of 4 meeting Action Items) were previously completed per MWH July 7 email (Subject: “FMC Groundwater Flow Model Meeting Follow-up”) and attachments and EPA July 8 email (Subject: “Re: FMC Groundwater Flow Model Meeting Follow-up”) and attachment.

The FMC GW transport model and preliminary predictive simulations meeting has been rescheduled for August 18 in Pocatello at the DEQ office. A draft agenda for the meeting that will also include a site tour will be circulated next weeks.

Please contact me should you have questions or encounter difficulties accessing the files from the MWH ftp site. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com

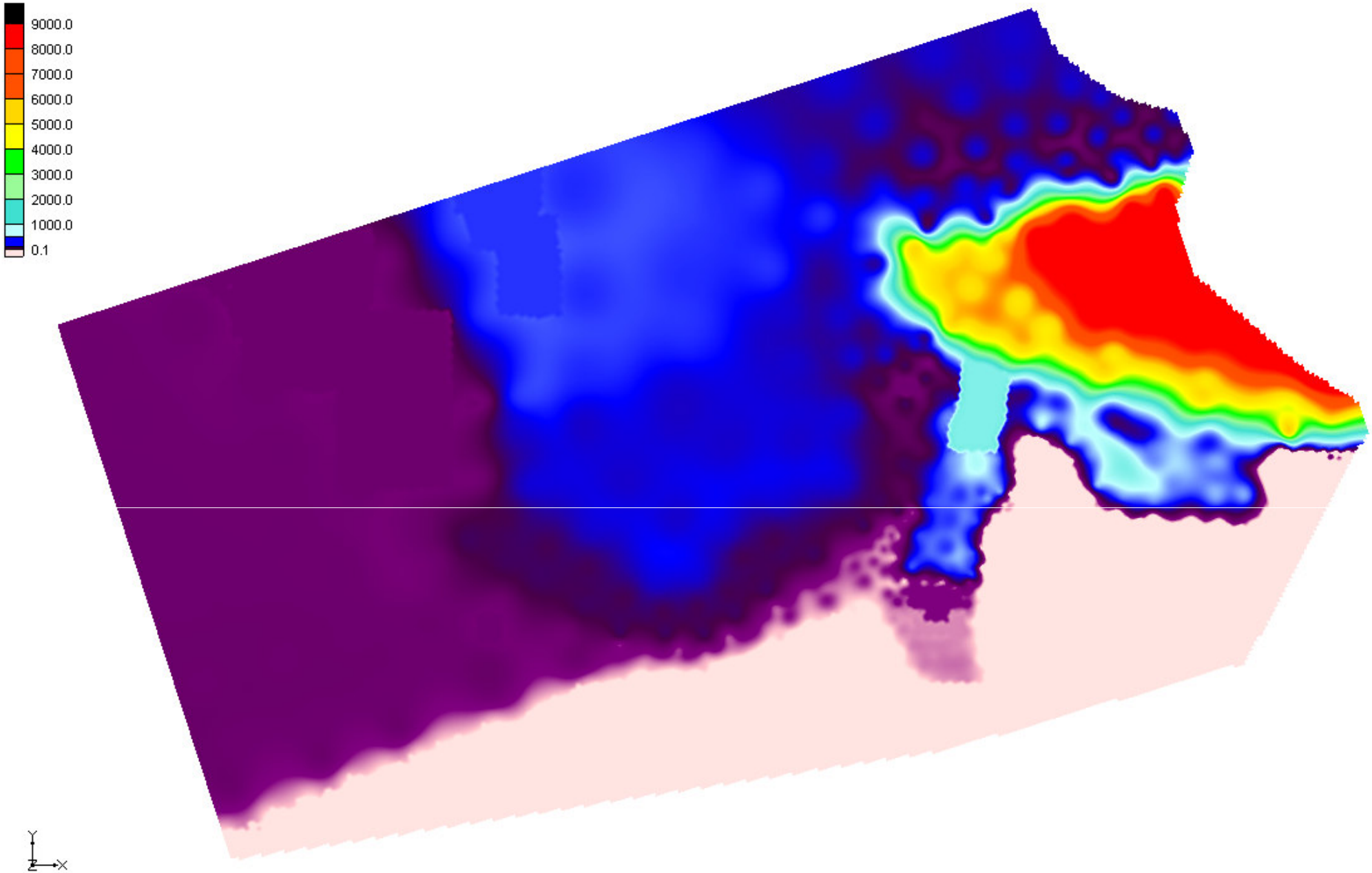


FMC Groundwater Flow Model
Model Domain

FMC Groundwater Flow Model

Hydraulic Conductivity Distribution (feet/day)

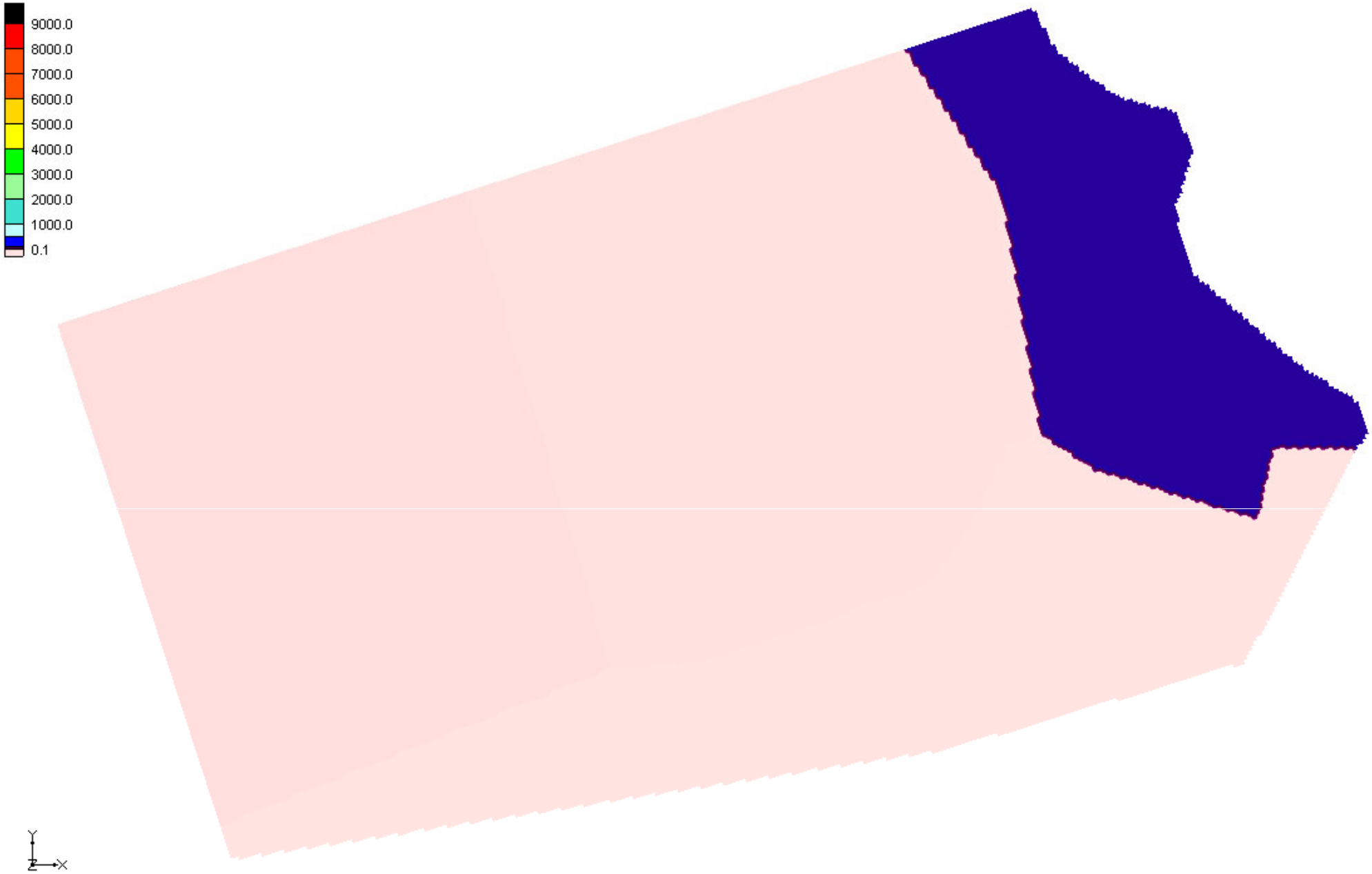
Upper Silt (Layer 1)



FMC Groundwater Flow Model

Hydraulic Conductivity Distribution (feet/day)

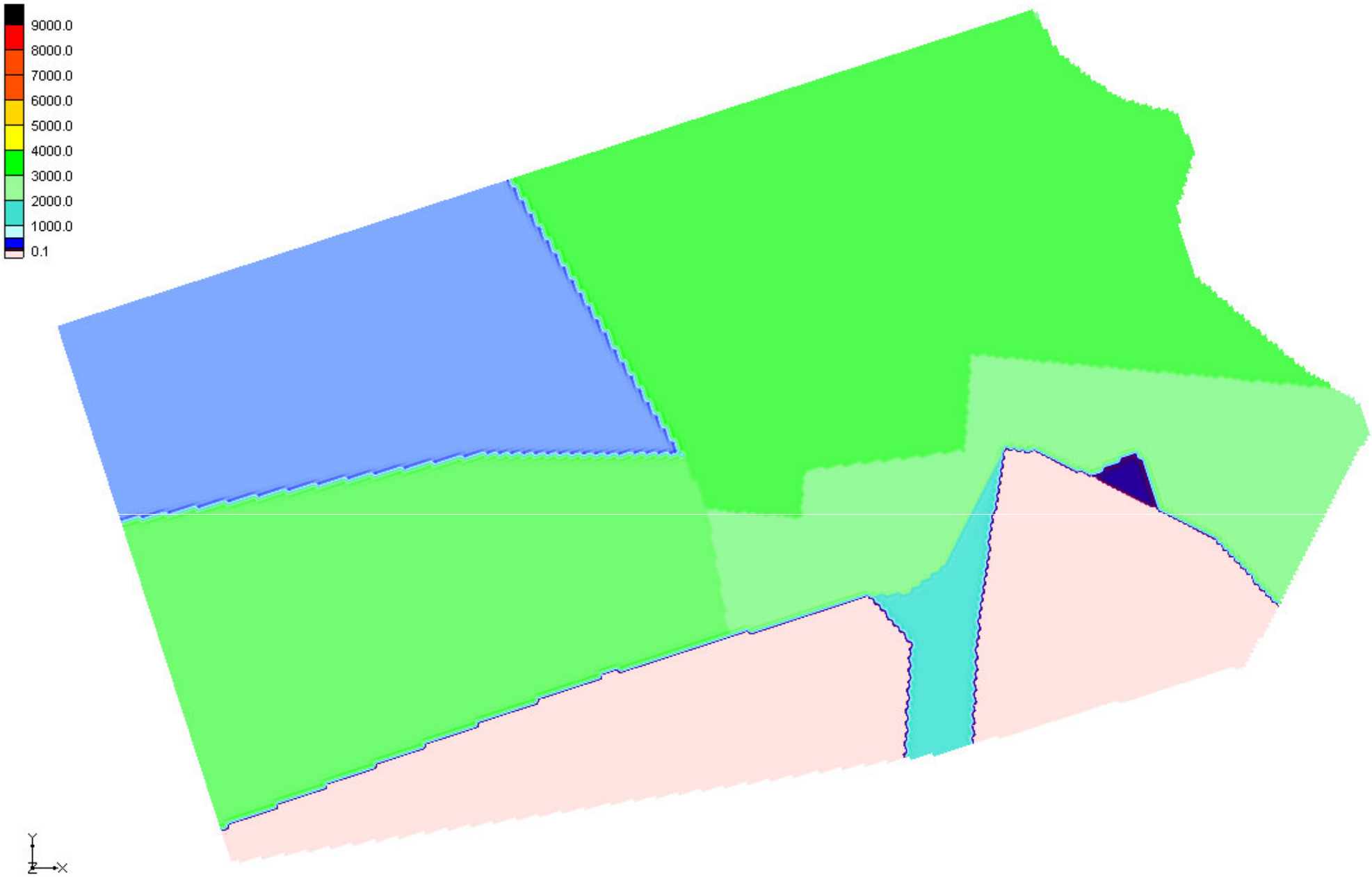
Upper Aquifer (Layer 2)



FMC Groundwater Flow Model

Hydraulic Conductivity Distribution (feet/day)

Lower Silt (Layer 3)



FMC Groundwater Flow Model

Hydraulic Conductivity Distribution (feet/day)

Lower Aquifer (Layer 4)

Rob Hartman

From: Rob Hartman
Sent: Friday, August 07, 2009 9:09 AM
To: Kira Lynch; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; Fisher.Carla@epa.gov; Ross.randall@epa.gov; mbeljin@cinci.rr.com
Cc: Barbara Ritchie; Marc Bowman; Douglas Oliver Jr.; Zachary Brown
Subject: Draft Agenda for August 17 and 18 FMC GW Model Meeting in Pocatello
Attachments: Draft Agenda for Aug 17-18, 2009 FMC GW Xport Model Meeting.pdf

The draft agenda for the August 17 (site tour) and 18 FMC groundwater flow and transport model meeting agenda is attached. I will be out of the office all next week so if you have comments or questions please contact Marc Bowman. I look forward to meeting with you in Pocatello on the 17th and 18th. Thank you, Rob.

Rob J. Hartman, P.G.
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(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Draft Agenda for Agency-FMC Meeting on FMC Groundwater Flow and Transport Model
August 17, 2009, FMC Site Tour
August 18, 2009, DEQ Office, Pocatello, ID

August 17, 2009

3:30 Site Tour for those interested. Meet at the FMC trailers, tour will include FMC Plant Site and areas northeast of the plant including the springs at the Portneuf River. Long pants and sturdy shoes required, but no other special safety gear will be needed.

August 18, 2009

8:30 Introductions

8:40 Review Groundwater Flow Model and final calibration results

9:00 Groundwater Transport Model

- Parameter inputs (plume maps, analytical data, contaminant time series, contaminant mass estimates, and contaminant transport parameters)
- Calibration / Plume matching

10:00 Break

10:15 Preliminary predictive simulations

- Assumptions for non-FMC source/sinks
- Review preliminary results for conceptual remedial alternatives

11:30 Meeting recap and wrap-up

FMC
Supplemental Feasibility Study
Groundwater Modeling Update

August 18, 2009
Pocatello, Idaho

MWH

BUILDING A BETTER WORLD

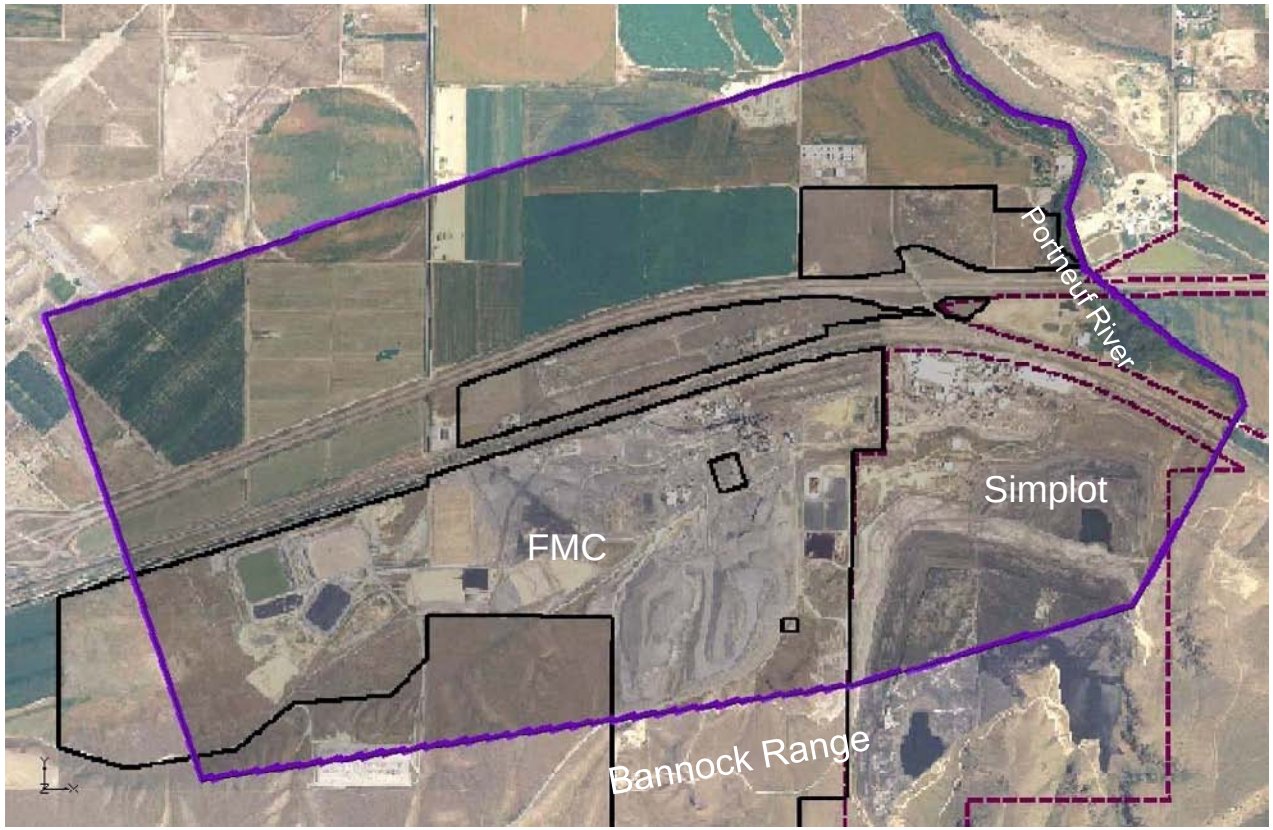
Modeling Objectives

- Development of a tool that can support the Supplemental Feasibility Study and compare remedial alternatives for the FMC Plant Operable Unit of the Eastern Michaud Flats Superfund Site
- Groundwater flow model was developed to provide the underlying flow regime for contaminant fate and transport simulations

Flow Model Overview

Domain approximately 15,500 by 9,000 feet – 2,862 acres

50 ft by 50 ft cells (50,463 per layer – total 201,852 cells)



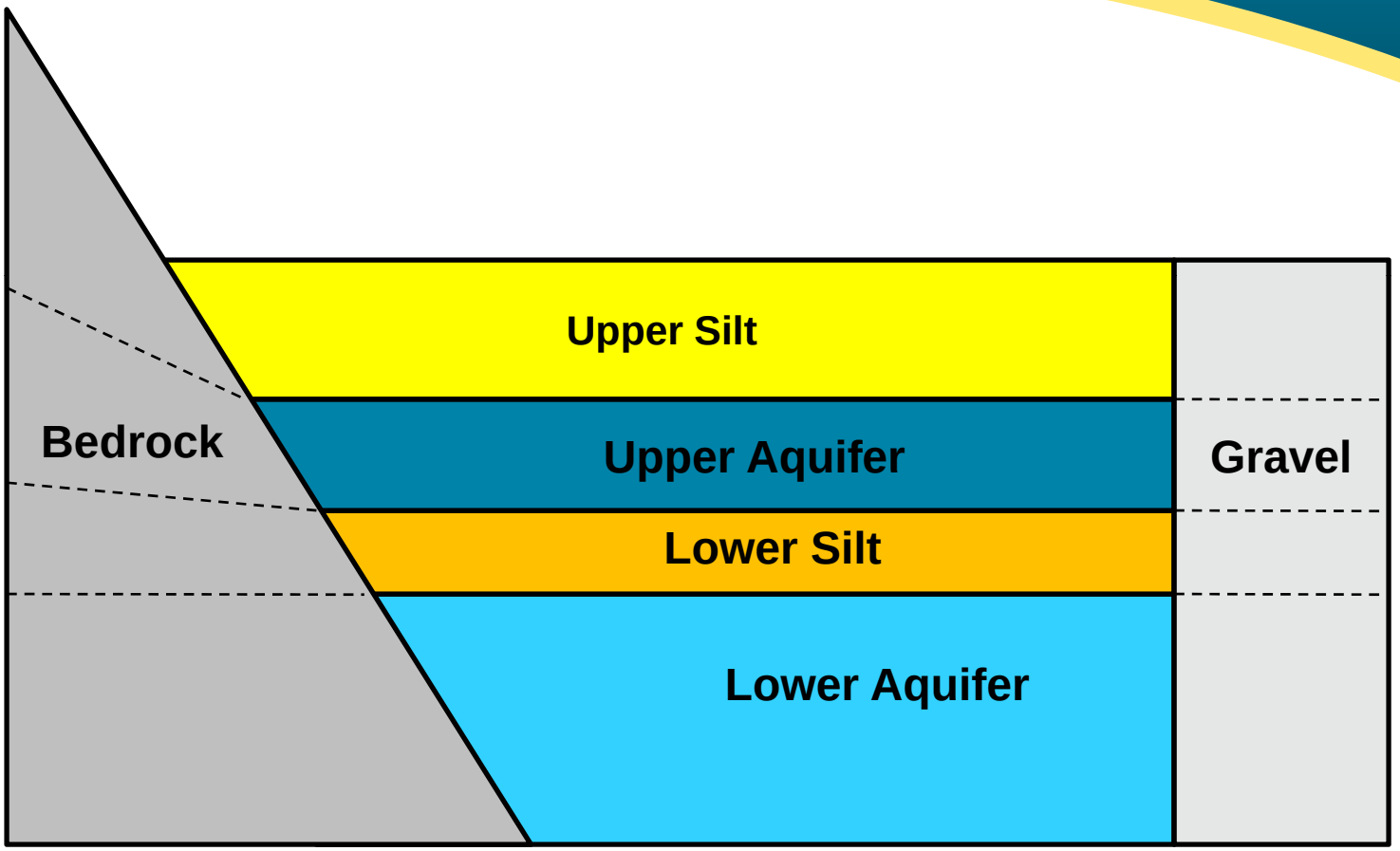
Layering

In general, the model layering scheme is based upon the major hydrogeologic units identified in the RI:

- Layer 1 = Upper Silt/volcanic bedrock/gravel
- Layer 2 = Upper Aquifer Zone/volcanic bedrock/gravel
- Layer 3 = Lower Silt/volcanic bedrock/gravel
- Layer 4 = Lower Aquifer Zone/volcanic bedrock/gravel

Clear distinctions between units are not always present and the vertical discretization is not necessarily based on stratigraphy near the Bannock Range and the Portneuf River

Layering


Upper Silt
Bedrock
Upper Aquifer
Gravel
Lower Silt
Lower Aquifer

Calibration Statistics for Final Flow Model

Range of errors = -6.2 ft to +4.3 ft

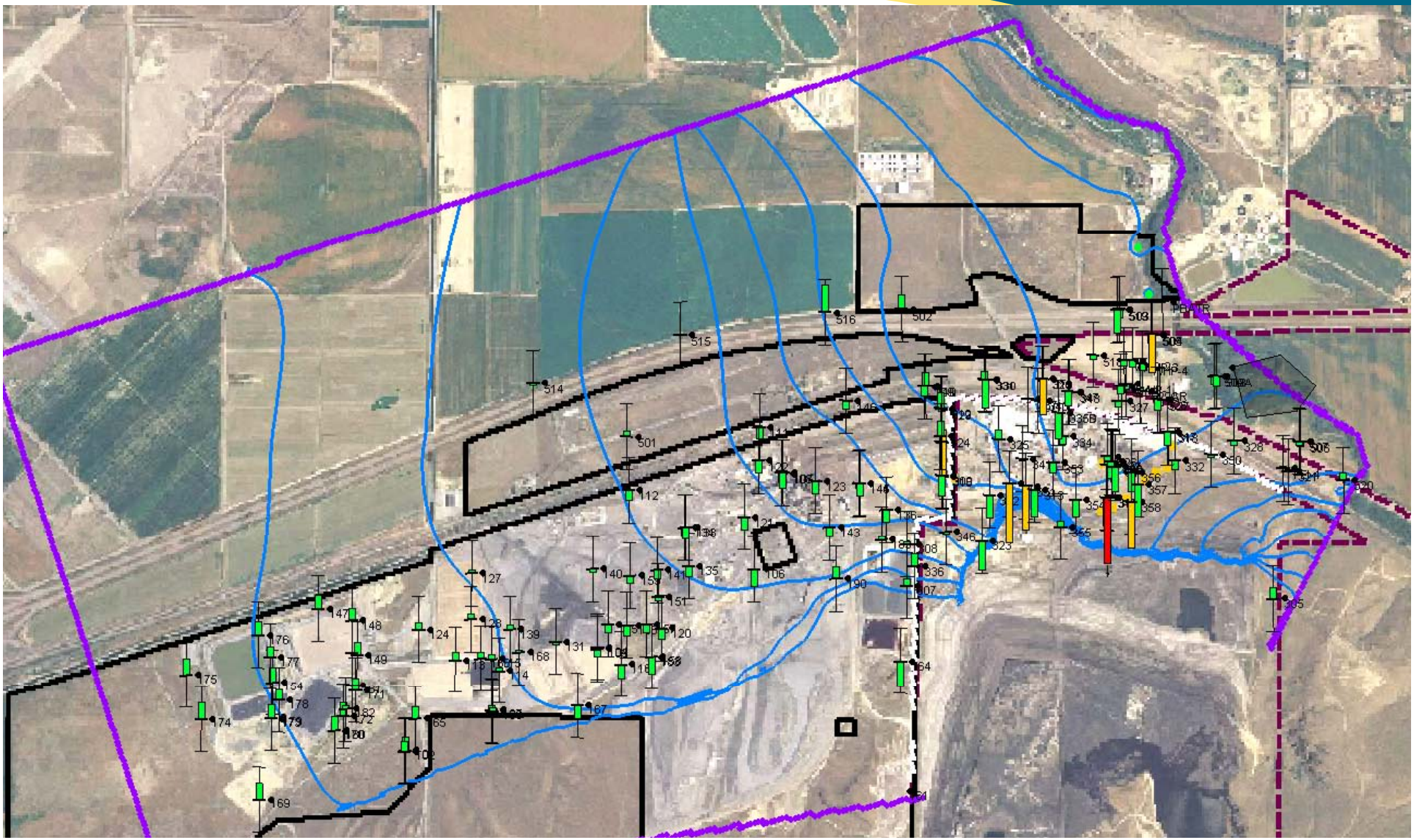
Average error = -0.4 ft

Absolute average error = 1.1 ft

Root mean squared error = 1.5 ft

Normalized root mean squared error = <1%

Distribution of Errors (Modeled – Observed)



Flow Model Sensitivity Analysis

Parameters modified were:

- Hydraulic conductivity
- Net recharge
- Spring conductance
- River stage

Sensitivity Analysis Results

Run	ME	MAE	RMSE	Normalized RMSE	Flux to River	Flow to Springs	Flow From Bannock Range
Base	-0.44	1.10	1.49	--	40	11	15
K x 2	-0.35	1.05	1.54	1.03	85	18	30
K / 2	-0.58	1.49	2.18	1.46	18	6	7
River + 3 ft	0.76	1.28	1.58	1.06	25	29	15
River - 3 ft	-1.63	2.47	3.90	2.62	100	0	15
Spring Conductance x 10	-0.47	1.11	1.50	1.01	38	14	15
Spring Conductance / 10	-0.39	1.07	1.46	0.98	44	4	15
Recharge x 2	-0.09	1.19	1.91	1.28	40	11	14
Recharge / 2	-0.50	1.26	2.00	1.34	39	11	15

Flow Model Summary

- Follow-up from July 1st meeting
  1. FMC/MWH posted MODFLOW files
  2. FMC/MWH distributed pdf file with hydraulic conductivity field
  3. FMC/MWH distributed well/boring log information used to construct model layers
  4. EPA provided guidance regarding Simplot future source/sinks
- Sensitivity analysis completed
- Flow model adequately calibrated

Contaminant Transport Model

Purpose and Objectives

- To simulate transport of the primary contaminant and indicator parameters
- Support the SFS and remedial alternatives development
- To evaluate and optimize remedial alternatives

FMC Source Areas

- Pond 8S (RU 22a)
- Old “Phossy” Ponds (RU 22b)
- Furnace Building, Phos Dock and Secondary Condenser (RU1) and Slag Pit (RU2)
- Former Kiln Scrubber Ponds and Calciners (RU 8) and Former Kiln Scrubber Overflow Pond (RU 9)
- Former Unlined Calciner Ponds and Calciner Sediment Storage Area ‘A’ (RU 14)
- Calciner Solids Storage Area (RU 16)

Contaminants Simulated

- Arsenic
  - Primary risk driving groundwater COC
- Total Phosphorus/Orthophosphate
  - Primary (groundwater to) surface water COC
- Potassium
  - Key indicator of FMC source areas

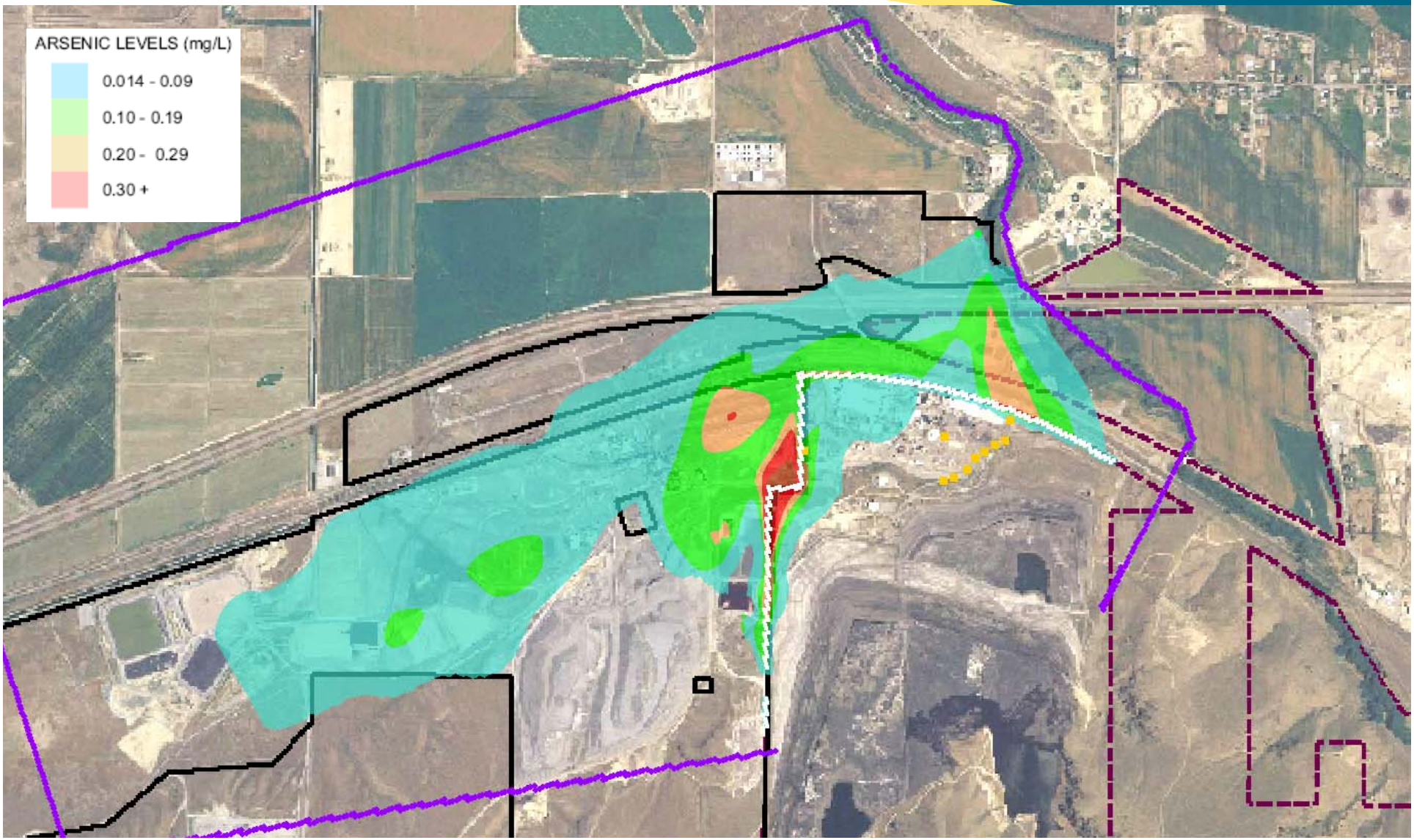
Transport Model Calibration

Plume Matching Process

- 1994 plumes used as initial conditions
- Ongoing sources assumed at Pond 8S, Old Phossy Ponds 3E-6E (beneath Pond 15S area), and Simplot
- Plume matching process involved adjusting sorption/retardation, dispersivity, porosity, and source strength
- Simulated contaminant plumes were compared to plume maps generated with measured concentrations (average 2006-2008)

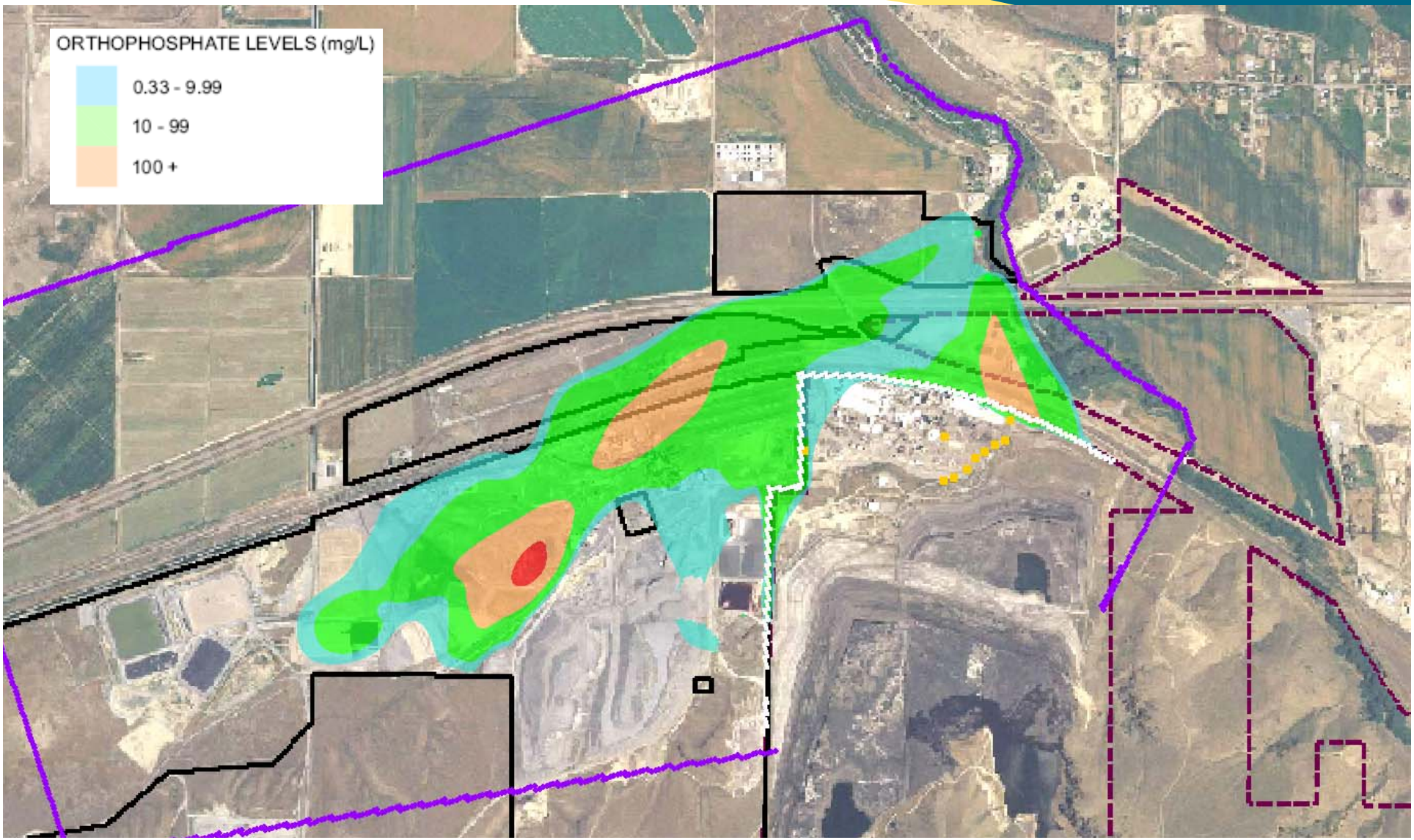
Model-Predicted Arsenic Plume (2008)

Preliminary – Subject to Change



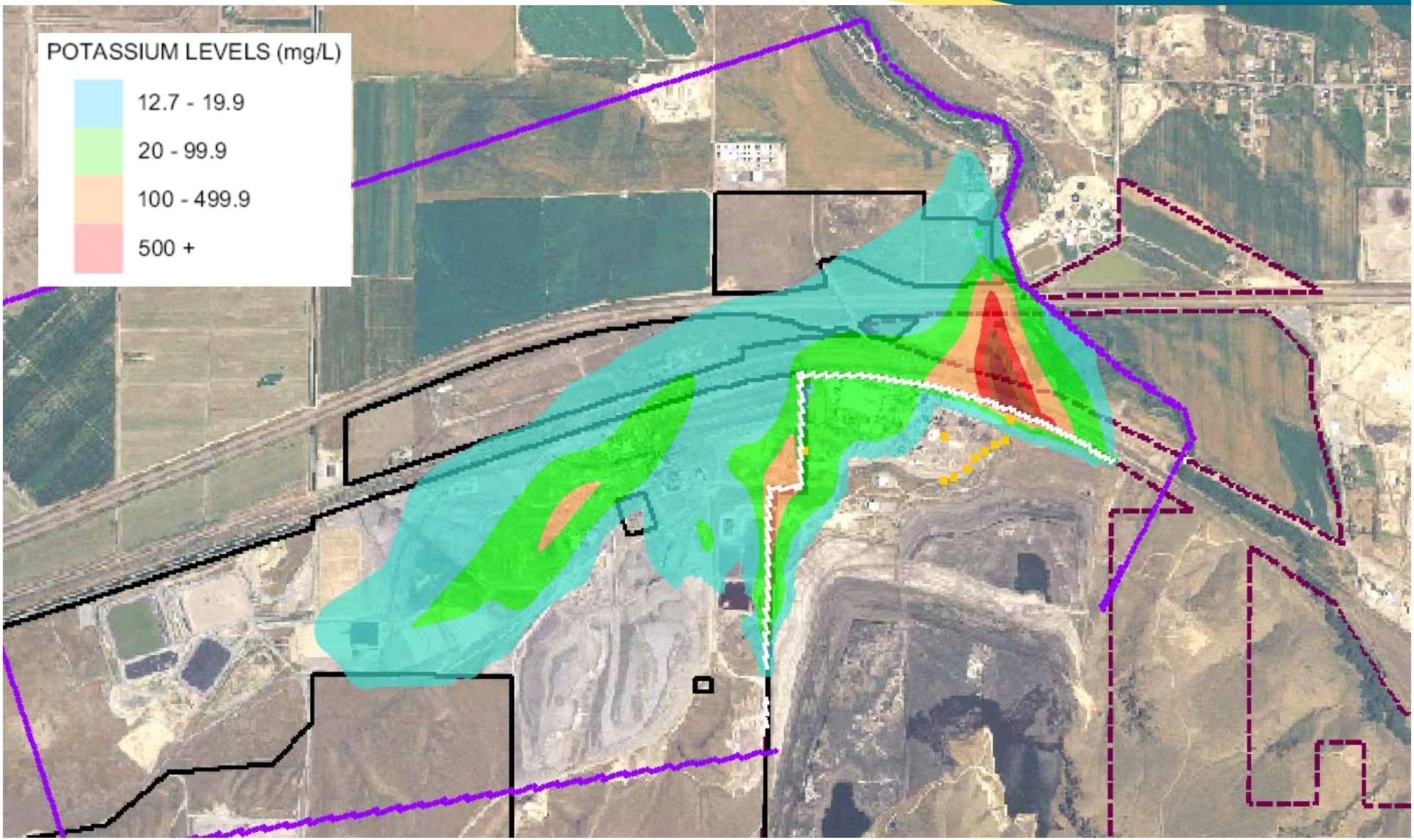
Model-Predicted Orthophosphate Plume (2008)

Preliminary – Subject to Change



Model-Predicted Potassium Plume (2008)

Preliminary – Subject to Change



Plume Matching Summary

- 2008 plume lengths and widths matched for arsenic, orthophosphate, and potassium
- 2008 distribution of contamination matched reasonably well
- Measured 2008 contaminant data will be imported for predictive simulation initial conditions

Calibrated Transport Parameters

Effective Porosity

- 30 percent

Dispersivity

- Initial Estimate of 55 feet based on plume length method (Xu & Eckstein, 1995)
- Final calibrated value of 20 feet

Sources

- Pond 8S
  - 0.62 mg/l Arsenic, 500 mg/l Potassium, 3700 mg/l Phosphate
- Pond 3E-6E
  - 0.62 mg/l Arsenic

Calibrated Transport Parameters

Sorption and Retardation

- Arsenic
  - K_d = 2.8 ml/g
  - R = 15
- Orthophosphate
  - K_d = 1.0 ml/g
  - R = 6
- Potassium
  - K_d = 2.6 ml/g
  - R = 14

Predictive Simulations of GW Alternatives

GW Alternative 1

- Source Controls (i.e., Soil Remedial Actions)
- Institutional Controls (Prevent use/ingestion of site-impacted groundwater)
- Long-term groundwater monitoring

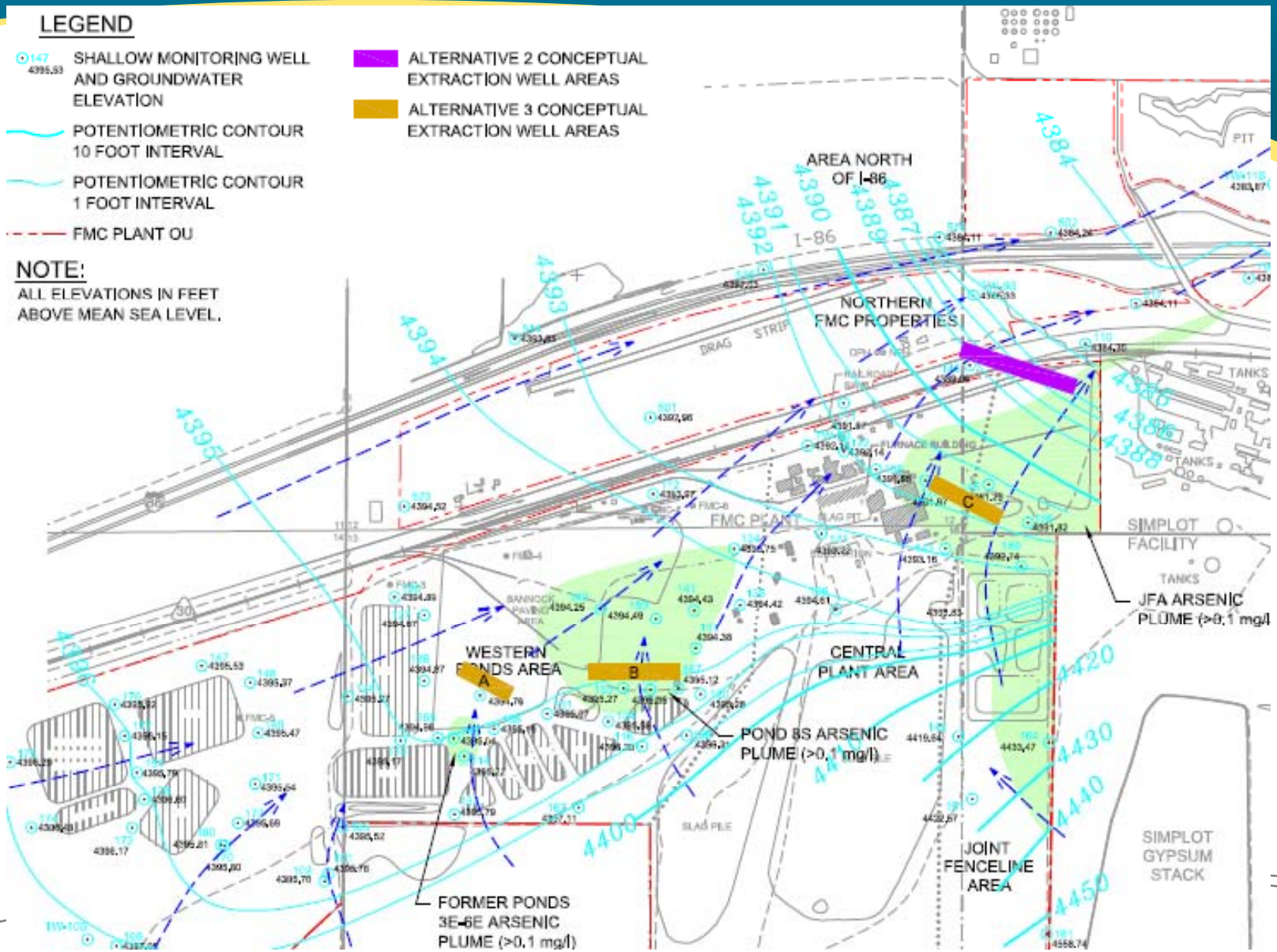
GW Alternative 2

- Alternative 1 components
- Groundwater extraction for hydraulic containment at plant boundary
- Treatment and/or use of extracted groundwater

GW Alternative 3

- Alternative 1 components
- Groundwater extraction at identified source areas
- Treatment and/or use of extracted groundwater

Predictive Simulations of GW Alternatives



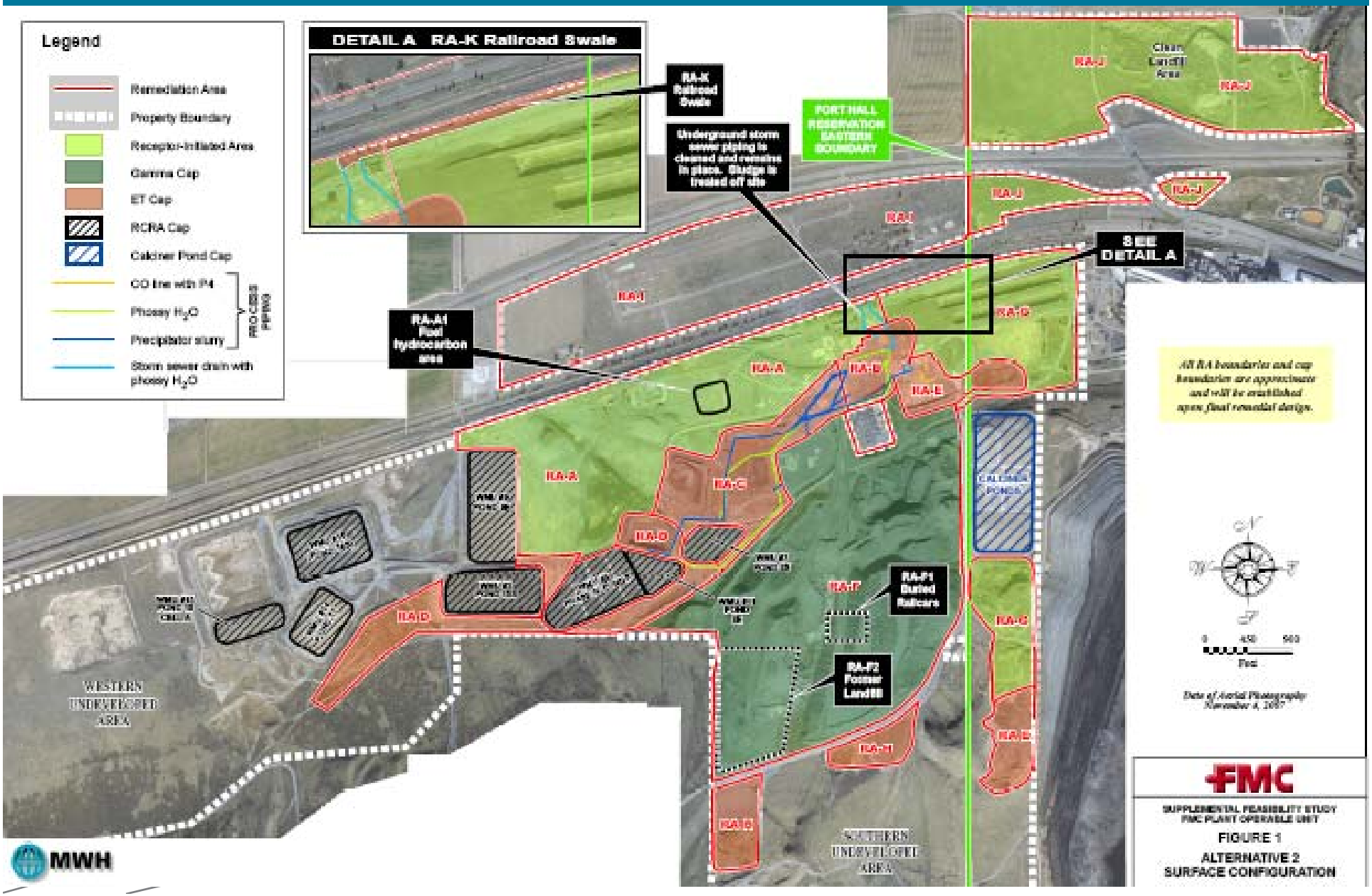
Predictive Simulations

- Initial conditions for contaminant distribution based on 2008 data
- Simplot
  - recharge from gyp stack = ~900 gpm (2009-2015)
  - recharge from gyp stack = 0 (after 2015)
  - pumping assumed constant based on 2008 rates
  - specified concentration at fence line based on 2008 data
- Steady-state flow model (2009-2015, 2015+)

Predictive Simulations (continued)

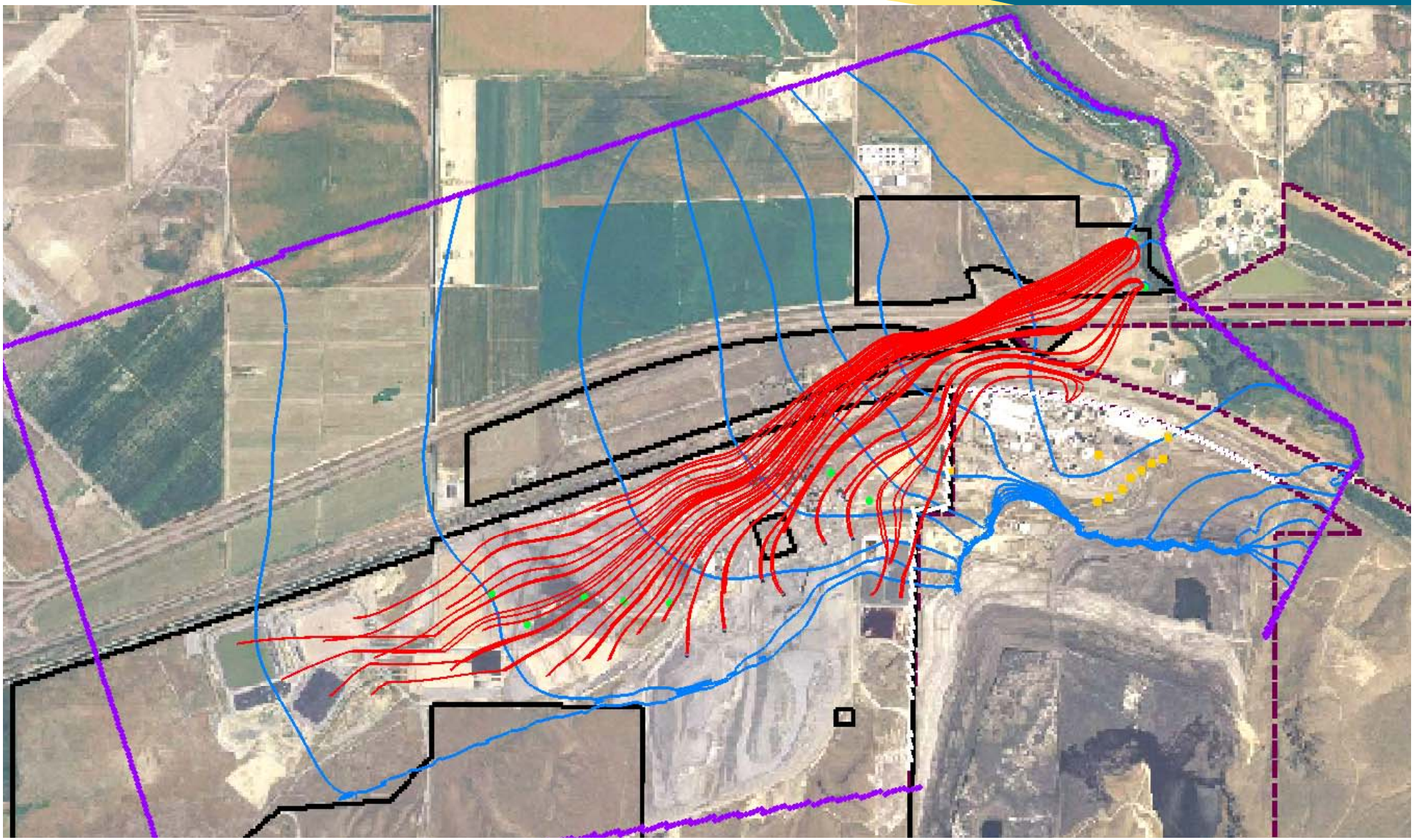
- Existing caps incorporated in calibrated flow model
  - RCRA and Calciner Pond Caps assigned infiltration rate = 2×10^{-5} inch/year
- SFS Assembled Soil Alternatives
  - Soil Alternative 2 ET Cap RAs assigned infiltration rate = 0.05 inch/year
  - Gamma Cover = natural infiltration rate = 1.2 inch/year
  - No changes in recharge would result from soil alternatives that include excavation and removal

Soil Alternative 2



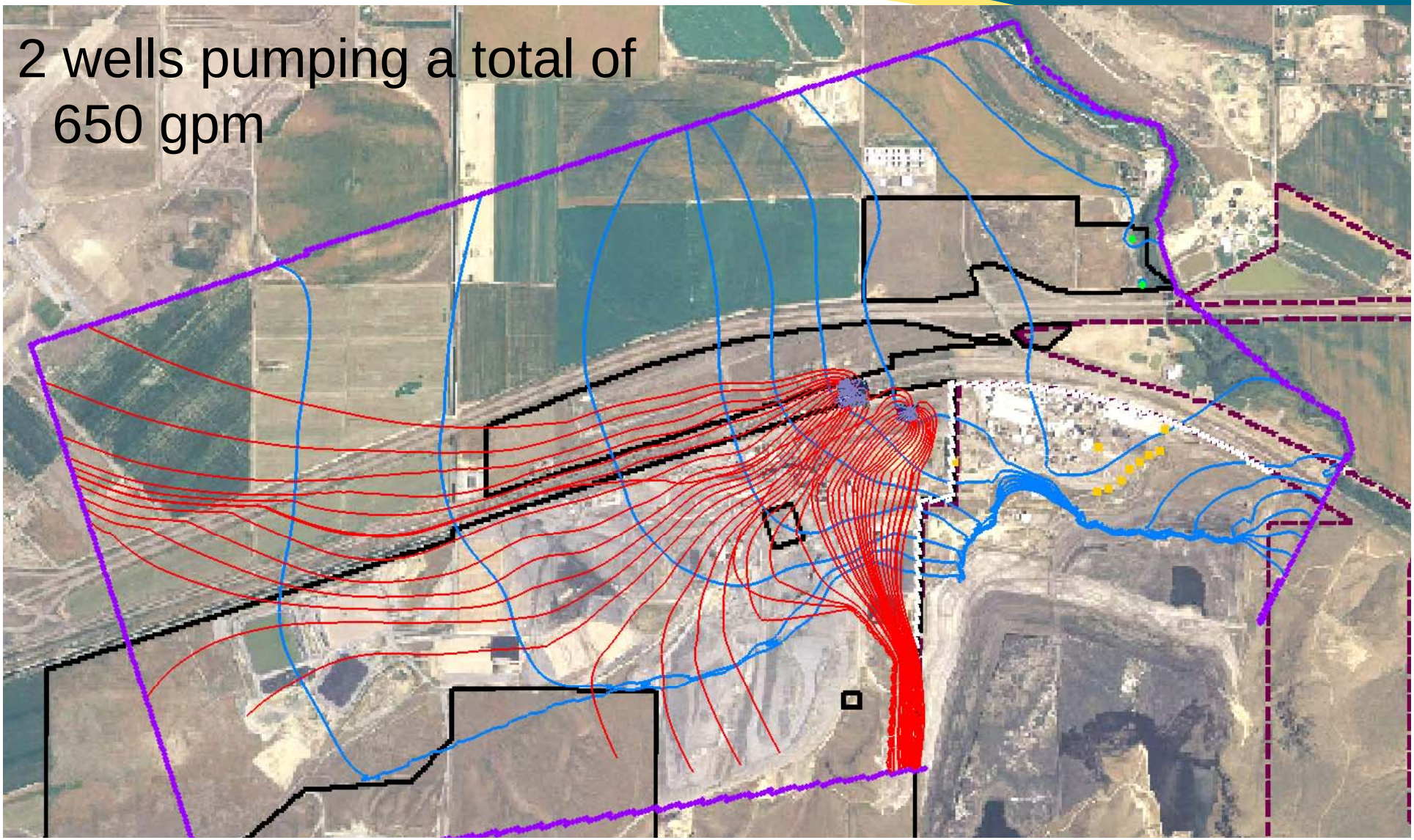
GW Alternative 1: Forward Particle Tracking

Preliminary – Subject to Change



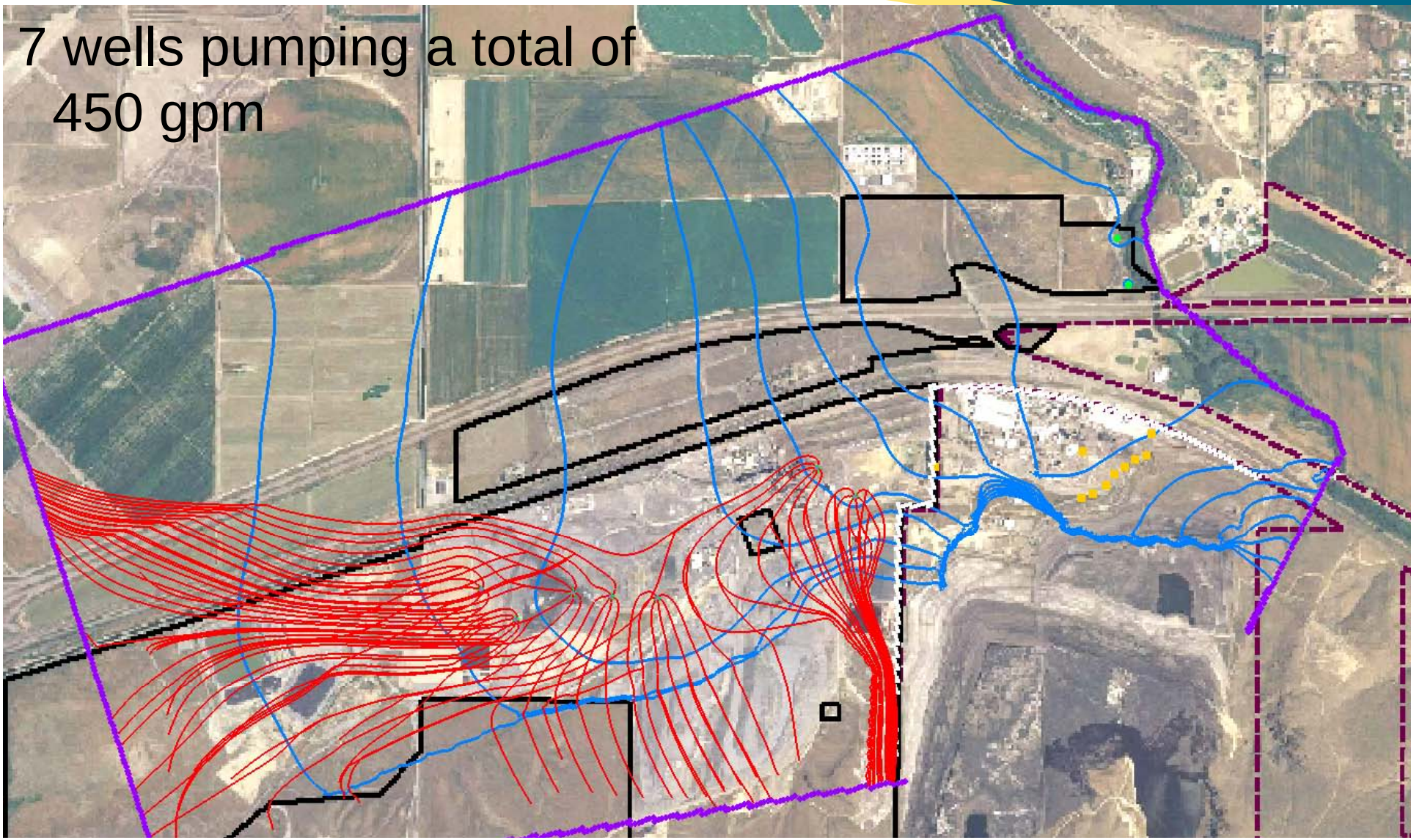
GW Alternative 2: Capture Zones

Preliminary – Subject to Change



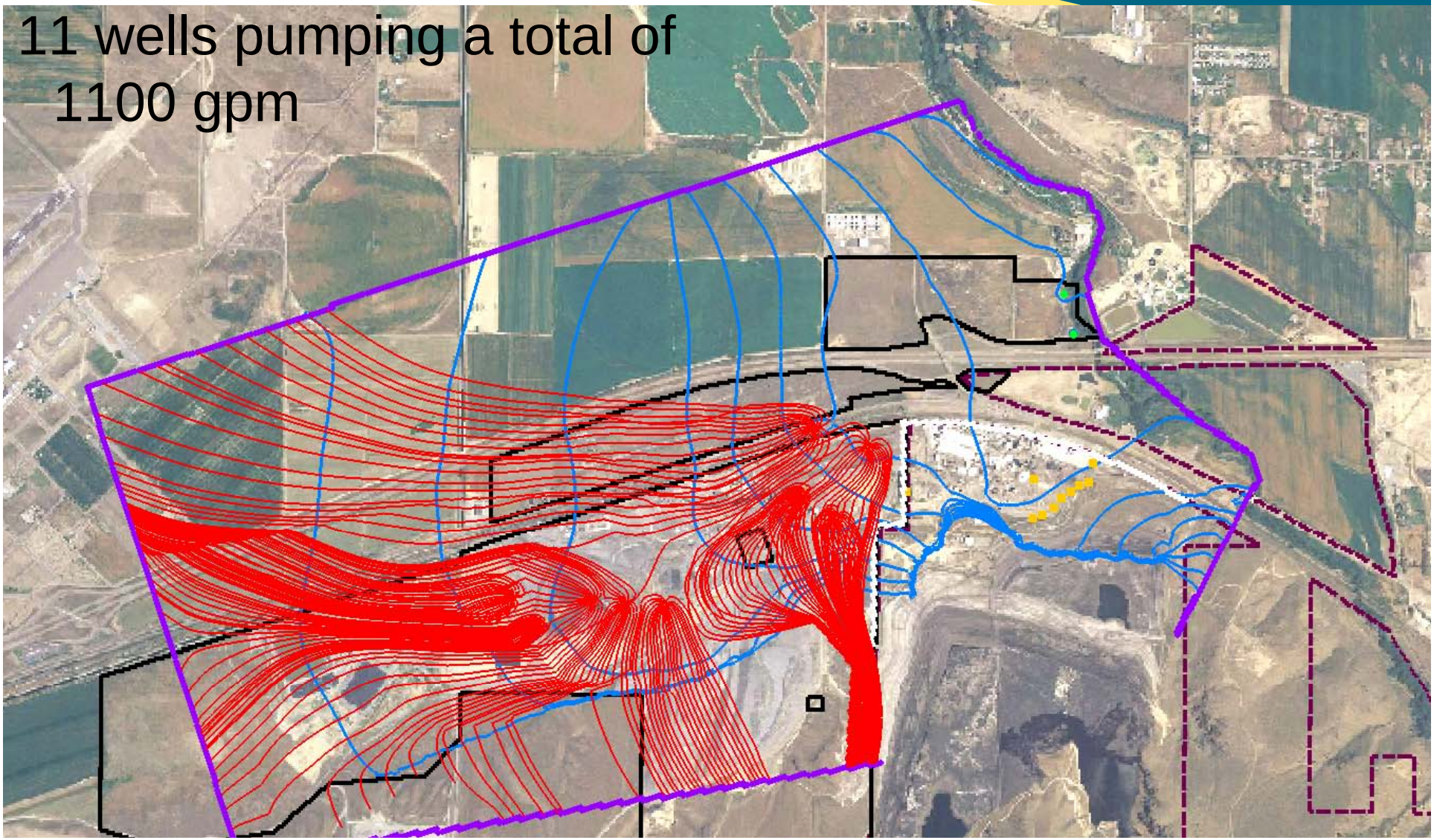
GW Alternative 3: Capture Zones

Preliminary – Subject to Change



Combination of GW Alternatives 2 and 3

Preliminary – Subject to Change



Path Forward

- Comments on preliminary contaminant transport model calibration
- Complete predictive simulations
- Hold teleconference to review predictive results
- Prepare model report (presented as appendix to SFS report)

Rob Hartman

From: Rob Hartman
Sent: Thursday, August 20, 2009 9:27 AM
To: 'Lynch.Kira@epamail.epa.gov'; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; 'Fisher.Carla@epa.gov'; 'Ross.Randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: Barbara Ritchie; Marc Bowman; Douglas Oliver Jr.; Zachary Brown; 'Prouty, Alan L'; 'Andy Koulermos'
Subject: August 18, 2009 FMC Groundwater Model Meeting Follow-up
Attachments: FMC SFS GW Model 18Aug09 - final.pdf

During the FMC groundwater model review meeting on August 18, 2009, we captured the following list of action items:

1) Provide a copy of the meeting presentation slides to the "FMC groundwater model group" distribution list. Per request by Bernie Zavala, Alan Prouty and Andy Koulermos have been added to the distribution. **Follow-up:** Meeting presentation slides attached to this email.
2) MWH to post the GMS / MODFLOW files for the final calibrated flow model on the MWH ftp site. **Follow-up:** MWH has posted the GMS / MODFLOW files for the final calibrated flow model discussed during the meeting for access by agency personnel. These files can be opened with GMS Version 6.5 or higher. These files have been posted to the MWH Ftp site in the folder "FMC Flow" and will remain on the Ftp site for 30 days.
3) MWH to compile the quarterly groundwater potentiometric (contour) maps for the FMC Plant OU into a readily accessible form. **Follow-up:** MWH has posted the quarterly groundwater potentiometric maps covering the period 1992 through 2008 in a single pdf file named "FMC Qtrly GW Contour Maps 1992 - 2008.pdf." This file has been posted to the MWH Ftp site in the folder "GW Contour Maps" and will remain on the Ftp site for 30 days.
4) MWH will review EMF RI data sources (e.g., USGS pump test data) used to assign hydraulic conductivity in model layer 2 in the northeastern portion of the model domain.
5) EPA and FMC/MWH will coordinate to firm up the planned conference call on September 3 to discuss any additional comments on the calibrated flow model and preliminary remedial alternatives, and to coordinate a webcast meeting on or about September 22 to discuss any comments on the calibrated transport model. In advance of the webcast meeting, MWH/FMC will post the calibrated transport model files on the MWH ftp site by September 15.

MWH Ftp login information and instructions:

The ftp site link is: ftp.mwhglobal.com
Username: slc1-FMC
Password: polonium

Instructions for accessing the Ftp site with Internet Explorer 5.0 or higher:

- Open Browser and go to ftp.mwhglobal.com
- Go to File on your drop down menu and select "Login As" – the login menu should pop-up automatically if you have Explorer 7.0 or higher.
- Enter "slc1-FMC" for the user name and "polonium" for the password. This will log you in and display the files that have been loaded onto the site.
- Select the folder "FMC Flow" and open for GMS/MODFLOW files.
- Select the folder "GW Contour Map" and open for "FMC Qtrly GW Contour Maps 1992 - 2008.pdf."
- Select the files you need, right click on one and use the "Copy To Folder" option on the popup menu to save files to your local computer (Explorer 7.0 or higher should allow 'drag and drop' copying to local computer).

We also plan to circulate meeting minutes later this week or early next week. Contact me should you have questions regarding this information. Thank you, Rob.

Rob J. Hartman, P.G.
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(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Rob Hartman

From: Rob Hartman
Sent: Thursday, August 27, 2009 9:59 AM
To: 'Lynch.Kira@epamail.epa.gov'; 'Zavala.Bernie@epamail.epa.gov'; 'Scott.Miller@deq.idaho.gov'; 'Doug Tanner'; 'Kelly Wright'; 'Susan Hansen'; 'Fisher.Carla@epa.gov'; 'Ross.Randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: 'Barbara Ritchie'; Marc Bowman; Douglas Oliver Jr.; Zachary Brown; 'Prouty, Alan L'; 'Andy Koulermos'
Subject: Minutes from August 18 2009 FMC GW Modeling Meeting and Schedule Follow-up
Attachments: FMC GW Flow Model Meeting Minutes 18Aug09.pdf; FMC SFS GW Model 18Aug09 - final.pdf

On behalf of FMC, I am routing a copy of the meeting minutes for the August 18, 2009 FMC Groundwater Modeling Meeting. The meeting presentation is also attached to the meeting minutes (and to this email).

Per my telephone conversation with Bernie yesterday, the follow-up conference call to discuss any additional comments on the calibrated flow model and preliminary remedial alternatives is scheduled for September 3 at 09:00 PDT / 10:00 MDT / 12:00 EDT. Dial in information:

Teleconference number: 888-403-8897
Participant code: 2152996700

Based on Bernie and Kira's availability, the meeting to discuss any comments on the calibrated transport model has tentatively been scheduled for the afternoon of September 21 in Pocatello. The FMC/MWH team is available for a meeting on September 21. Bernie still needs to check Milovan and Randall's availability as well as availability / interest on the part of DEQ and the Shoshone Bannock Tribes. In order to accommodate Milovan and Randall, we may conduct the meeting as a webcast. Additional details will follow pending confirmation of date and time for the meeting.

Contact me if questions. Thank you, Rob.

Rob J. Hartman, P.G.
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(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Meeting Minutes
FMC Plant OU SFS Groundwater Modeling Meeting
Idaho DEQ Offices, Pocatello, Idaho
Conducted on August 18, 2009

Attendees:

U.S. EPA:	Bernie Zavala, Randall Ross, Milovan Beljin
Idaho DEQ:	Scott Miller, Doug Tanner
FMC:	Barbara Ritchie (*)
MWH:	Marc Bowman, Rob Hartman, Zak Brown, Doug Oliver

(*) via teleconference:

Site Visit (August 17, 2009)

Rob Hartman gave a site tour on August 17 that was attended by Bernie Zavala, Randall Ross, and Milovan Beljin of the EPA, as well as Marc Bowman and Doug Oliver of MWH. The tour covered most of the FMC plant site and then proceeded to the Portneuf River and included observation of Batiste Spring, Swanson Road Spring and the reach between these springs.

Key issues and discussion topics

The purpose of this meeting was to present the final calibrated groundwater flow model, flow model sensitivity analysis results, transport model calibration, and preliminary predictive simulations of the SFS alternatives and get buy-in from the group on the groundwater flow and contaminant transport model calibration.

Rob Hartman, Doug Oliver, and Zak Brown gave a presentation on the calibrated groundwater flow and preliminary contaminant transport modeling performed to date. The associated PowerPoint presentation was converted to a pdf and is attached.

The following paragraphs summarize the main issues, comments, and questions that were raised during this meeting:

Flow Model Calibration

All follow-up items assigned to FMC/MWH from the July 1st meeting were completed.

EPA and IDEQ could not open the MODFLOW files posted by MWH/FMC. EPA (Milovan) has acquired GMS version 6.5, so should be able to open the files. IDEQ (Scott) has GMS version 3.1 and is not planning on looking at the files.

Milovan asked about the boundary conditions used (what were they and how were they set) and sources of recharge. Specified heads were set around much of the domain. No flow boundaries were set to the south of Simplot's gypsum stack. The springs were simulated with the drain package. Specified heads were based on 2008 water levels, but water levels have changed very little through time (both seasonally and in the long-term; generally on the order of a couple of feet). Areal recharge was 1.2 inch/year (~10% of annual precipitation). Additional recharge was not added beneath agricultural areas. Recharge was 2X10-5 inch/year beneath the RCRA caps, based on results of HELP modeling. The Taghee irrigation canal located along the northwestern boundary of the FMC plant property was not included as a source in the model because recharge from this ditch is not observed in the water level data. The seasonal use of the Taghee canal and relatively low water losses are documented in the EMF RI Groundwater Flow Modeling Report and, like the EMF RI groundwater flow model, water losses from the canal through the model domain were assumed to be minimal compared to the overall water budget.

Randall questioned the hydraulic conductivity distribution (K-field). Specifically, the high hydraulic conductivity (K) of the Bonneville flood deposits near the springs and Portneuf River, particularly if they are like till. There was also discussion on the data sources used to assign a lower conductivity to model layer 2 in the area north of Batiste Spring (i.e., the northeast area of the model domain). The group reviewed K data (Table 3.3-1 from the EMF RI Report) and noted that K from the slug tests was generally lower than K from aquifer tests. The group also reviewed K data in the Draft Simplot Remedial Design Report (dated 5 Nov 08, but a newer draft exists dated 15 July 09).

The group agreed that the calibration of the groundwater flow model appeared adequate; however, Bernie stated that the model may need some fine tuning, particularly related to the K-field. MWH will review all available K data for the northeastern corner of the domain in an effort to further improve the reality of the K-field (potentially removing the half "bulls-eye" shaped high K zone in the northeast corner of the domain).

Contaminant Transport Model Calibration

MWH presented preliminary results of the plume matching effort performed to calibrate the transport model. The transport model includes simulation of arsenic, orthophosphate/total phosphorus, and potassium. Arsenic was selected because it is the primary risk driver in groundwater and defines the areal extent of groundwater impacts at the site. Total phosphorus was selected because of its widespread nature and due to potential impacts to surface water quality. Potassium was selected because it is a good indicator of FMC's groundwater source areas relative to those of Simplot. The period selected for calibration of the transport model was 1994-2008. Plumes constructed with measured 1994 data were used as initial conditions and the model was run forward to predict 2008 conditions. Model predicted plumes for 2008 were compared to plumes generated with 2006-2008 data. While plumes with sources at FMC were matched reasonably well, plumes with sources at Simplot were not matched as well because of the influence of the 1994 initial conditions in which the

East Overflow Pond at Simplot was one of the primary sources at the time. A qualifier will need to be included in the modeling report (to be included as an appendix to the SFS Report) that specifies that less effort was put into the calibration in the Simplot area.

Milovan asked about sorption (Kd) and retardation (R) values used in the model. Initial values were based on literature review and calibrated values from the Pond 8S Solute Transport Study which was included as a companion submittal with the 8S Closure Plan (Pond 8S and 8S Recovery Process), FMC Corporation, April 1, 1993. The literature values tended to be very high, allowing very little transport. The values we determined based on calibration were higher than the values used in the Pond 8S transport model, but were lower than literature values. While Kd and R are strongly pH dependent for arsenic, the pH of groundwater at FMC and downgradient of the FMC site is near neutral, ranging between 6.8 and 8.0. The only areas of low pH are on the Simplot site.

Predictive Simulations

Areal recharge to the flow model will be modified for predictive simulations to simulate the FMC assembled soil remedial alternative cap areas. Recharge beneath the ET caps will be based on UNSAT-H predictions. Recharge beneath gamma caps will be assumed to remain the same as natural recharge (10% of precipitation). The predictive simulations will use measured contaminant concentration data from 2006-2008 (presented in the Groundwater Current Conditions Report) for initial conditions. Simplot will be modeled as a constant concentration source at the fence line. No effort will be made to simulate contaminant concentrations on the Simplot site given that groundwater flow in the joint fence-line area is generally from the Simplot site toward the FMC site. While EPA's overall goal is to reduce overall loading of contamination from FMC and Simplot, the purpose of the model constructed by MWH/FMC is to perform a comparative analysis between the groundwater alternatives for the SFS.

MWH/FMC presented preliminary results from predictive simulations generated with MODFLOW and MODPATH to predict capture zones and contaminant transport flow directions. Results were presented for Groundwater Alternative 1 (which includes source controls and monitoring but no active groundwater extraction), Groundwater Alternative 2 (hydraulic containment with two wells), Groundwater Alternative 3 (pump and treat with wells in the former source areas), and a fourth alternative that included all wells from both Groundwater Alternative 2 and Groundwater Alternative 3.

Bernie was concerned about dewatering of wells, specifically the preliminary two well configuration may not be sufficient to sustain the preliminary extraction rate for Alternative 2. MWH/FMC will optimize the number of wells, well locations, and pumping rates. Scott asked about stagnation zones. These were evident in the MODPATH results, but the MT3D model is necessary to evaluate the impacts of these stagnation zones. The results presented were preliminary and will be optimized.

Bernie asked about the lower aquifer zone (Layer 4). Rob summarized the results of the 2Q2009 special shallow/deep well pair sampling and analysis regarding distribution of contamination in the upper and lower aquifer zones noting that the results were comparable to the findings described in the EMF RI and Groundwater Current Conditions Reports. There is an upward vertical hydraulic gradient from the deeper zone to the shallower zone in the northern / northeastern (downgradient) area of the plant site such that site groundwater contaminants do not exceed background levels as groundwater leaves the plant site.

Milovan stated that we should make sure that the domain boundary conditions do not unrealistically affect the predictive results. The model was constructed with a relatively large domain (15,500 feet by 9,000 feet) so as to avoid boundary effects.

Schedule

The group discussed overall project schedule. Barbara Ritchie noted that resolution of the agencies comments on the SRI Addendum is anticipated to delay the SFS by at least a month. Barbara stated she would communicate with Kira Lynch on overall project / SFS schedule. The following is a tentative schedule for the SFS groundwater modeling effort:

- 3 September 2009 - Teleconference with EPA to obtain feedback on flow model
- 22 September 2009 - Meet in Pocatello to discuss results of transport model calibration, sensitivity analysis, and preliminary predictive results.
- Late October 2009 - (estimated - to be determined by Kira Lynch and FMC) Groundwater modeling report to be submitted as an appendix to the Draft SFS.

Action Items

During the FMC groundwater model review meeting on August 18, 2009, we captured the following list of action items:

1) Provide a copy of the meeting presentation slides to the "FMC groundwater model group" distribution list. Per request by Bernie Zavala, Alan Prouty and Andy Koulermos have been added to the distribution. **Follow-up:** Meeting presentation slides attached to these minutes.
2) MWH to post the GMS / MODFLOW files for the final calibrated flow model on the MWH ftp site. **Follow-up:** MWH has posted the GMS / MODFLOW files for the final calibrated flow model discussed during the meeting for access by agency personnel. These files can be opened with GMS Version 6.5 or higher. These files have been posted to the MWH ftp site in the folder "FMC Flow" and will remain on the ftp site for 30 days.
3) MWH to compile the quarterly groundwater potentiometric (contour) maps for the FMC Plant OU into a readily accessible form. **Follow-up:** MWH has posted the quarterly groundwater potentiometric maps covering the period 1992 through 2008 in a single pdf file named "FMC Qtrly GW Contour Maps 1992 - 2008.pdf." This file has been posted to the MWH ftp site in the folder "GW Contour Maps" and will remain on the ftp site for 30 days.

4) MWH will review EMF RI data sources (e.g., USGS pump test data) used to assign hydraulic conductivity in model layer 2 in the northeastern portion of the model domain. FMC/MWH will provide any additional information/details from this review during the planned September 3 conference described in Item 5 below.
5) EPA and FMC/MWH will coordinate to firm up the planned conference call on September 3 to discuss any additional comments on the calibrated flow model and preliminary remedial alternatives, and to coordinate a webcast meeting on or about September 22 to discuss any comments on the calibrated transport model. In advance of the webcast meeting, MWH/FMC will post the calibrated transport model files on the MWH ftp site by September 15.

MWH ftp login information and instructions:

The ftp site link is: ftp.mwhglobal.com
Username: slc1-FMC
Password: polonium

Rob Hartman

From:	Rob Hartman
Sent:	Wednesday, September 02, 2009 1:25 PM
To:	'Lynch.Kira@epamail.epa.gov'; 'Zavala.Bernie@epamail.epa.gov'; 'Scott.Miller@deq.idaho.gov'; 'Doug Tanner'; 'Kelly Wright'; 'Susan Hansen'; 'Fisher.Carla@epa.gov'; 'Ross.Randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc:	'Barbara Ritchie'; Marc Bowman; Douglas Oliver Jr.; Zachary Brown; 'Prouty, Alan L'; 'Andy Koulermos'
Subject:	August 18 FMC GW model meeting Action Item 4 follow-up and Sept. 3 conference call reminder
Attachments:	USGS Report 84-4201 Table 1 and Annotated Fig 3.pdf; Wells 524 and 525 Boring Logs.pdf

Action item 4 identified in the FMC minutes for the August 18, 2009 groundwater model meeting is addressed below:

Action Item 4. MWH will review EMF RI data sources (e.g., USGS pump test data) used to assign hydraulic conductivity in model layer 2 in the northeastern portion of the model domain.

Follow-up: Per the footnote on the EMF RI Table 3.3-1 Hydraulic Conductivities and Transmissivities of the EMF Aquifer System, the USGS pump test data was taken from "Water-Resources Investigations Report 84-4201, Hydrogeology of Eastern Michaud Flats, Fort Hall Indian Reservation, Idaho" (Jacobson, 1984). The list of wells, pump test results and calculated transmissivities for the wells that were included on RI Table 3.3-1 are found on Table 1 of the USGS Report. The location of the wells is shown on Figure 3 of the USGS Report. A copy of Table 1 and an annotated copy of Figure 3 are attached to this email ("USGS Report 84-4201 Table 1 and Annotated Fig 3.pdf"). As shown on the annotated Figure 3, most of the USGS pump test wells are over 1 to 3 miles to the northwest outside of the FMC flow model domain. In addition, the wells that the USGS pump tested (primarily irrigation wells) produce from the deep aquifer zone and, thus, the pump test results are not relevant to the shallow zone (Flow Model Layer 2). Although Bechtel included the USGS data in the EMF RI Report, the data apparently was not used for the EMF RI groundwater flow model.

Based on a review of the EMF RI Groundwater Flow Modeling Report, Bechtel recognized a need for additional lithologic and hydrologic data north of Batiste Spring. As described in the EMF RI Groundwater Flow Modeling Report (Remedial Investigation Report, Eastern Michaud Flats Site, Appendix K, Bechtel, August 1996) on page 2-5, paragraph 2:

"Borings 524 and 525 were drilled approximately 150 feet north of the Batiste Spring building (Figure 2). These wells were installed to collect lithologic and water level data in support of this study. A shallow/deep well pair was installed in these borings. Silty gravels were logged to a depth of 112 feet below ground surface (bgs). A clay was encountered from 112 to 122 feet bgs, and a basalt underlies this clay. Although there were no distinct silt units encountered in these borings, the logs indicate a transition from extremely coarse, bouldery gravels immediately south of Batiste Spring to a siltier gravel north of Batiste Spring. This transition may reflect either a waning flood stage with a lower-energy depositional environment or significant reworking of flood deposits by the ancestral Portneuf River."

Based on the lithology encountered in borings 524/525, Bechtel assigned a hydraulic conductivity of 200 feet per day to the shallow aquifer zone in the area north of Batiste Spring which is comparable to the range of hydraulic conductivities assigned to Layer 2 in the northeastern area of the current calibrated groundwater flow model. Boring logs for wells 524 and 525 are attached ("Wells 524 and 525 Boring Logs.pdf").

Action items 1 through 3 (of 5 meeting Action Items) were previously completed per MWH August 20 email (Subject: "August 18, 2009 FMC Groundwater Model Meeting Follow-up") and attachment. Action item 5 from the meeting is in progress with the conference call scheduled on September 3 and meeting tentatively scheduled for September 21 in Pocatello.

As a reminder, the follow-up conference call to discuss any additional comments on the calibrated flow model and preliminary remedial alternatives is scheduled for September 3 at 09:00 PDT / 10:00 MDT / 12:00 EDT. Dial in information:

Teleconference number: 888-403-8897
Participant code: 2152996700

Contact me if questions. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Table 1.--Discharge, drawdown, specific capacity, and transmissivity of selected wells

Well No.	Casing diameter (inches)	Pumping period (hours)	Discharge (gallons per minute)	Drawdown (feet)	Specific capacity (gallons per minute per foot)	Estimated transmissivity (feet squared per day)	
						0.001	0.0001
5S-33E-32ACD1	10	24	1,430	13.27	108	31,400	35,100
32DDC1	10	24	1,560	3.75	416	121,000	135,700
33BAA1	10	48	867	13.32	65	19,600	21,900
33CCD1	8	24	738	10.96	67	20,000	22,400
34ADD1	10	120	2,330	19.77	118	37,200	41,400
34CBC1	11	168	1,666	14.56	114	36,400	40,400
34DCC1	11	168	1,606	15.51	104	32,900	36,600
35DDC1	11	168	1,894	4.08	464	148,000	164,000
6S-33E- 3ACD1	10	168	1,190	10.28	116	37,100	41,200
3BDC1	10	12	2,800	1.99	1,400	394,000	444,000
4BBA1	11	12	1,460	11.84	124	34,200	38,500
5BDA1	10	96	2,750	25.99	106	33,000	36,800
5DDB1	11	72	1,890	11.12	169	51,800	57,800
8ADA1	11	168	1,380	17.87	77	24,500	27,300
9CAC1	11	12	1,520	2.39	636	176,000	199,000
12BBC1	6	96	372	2.47	151	49,400	54,700

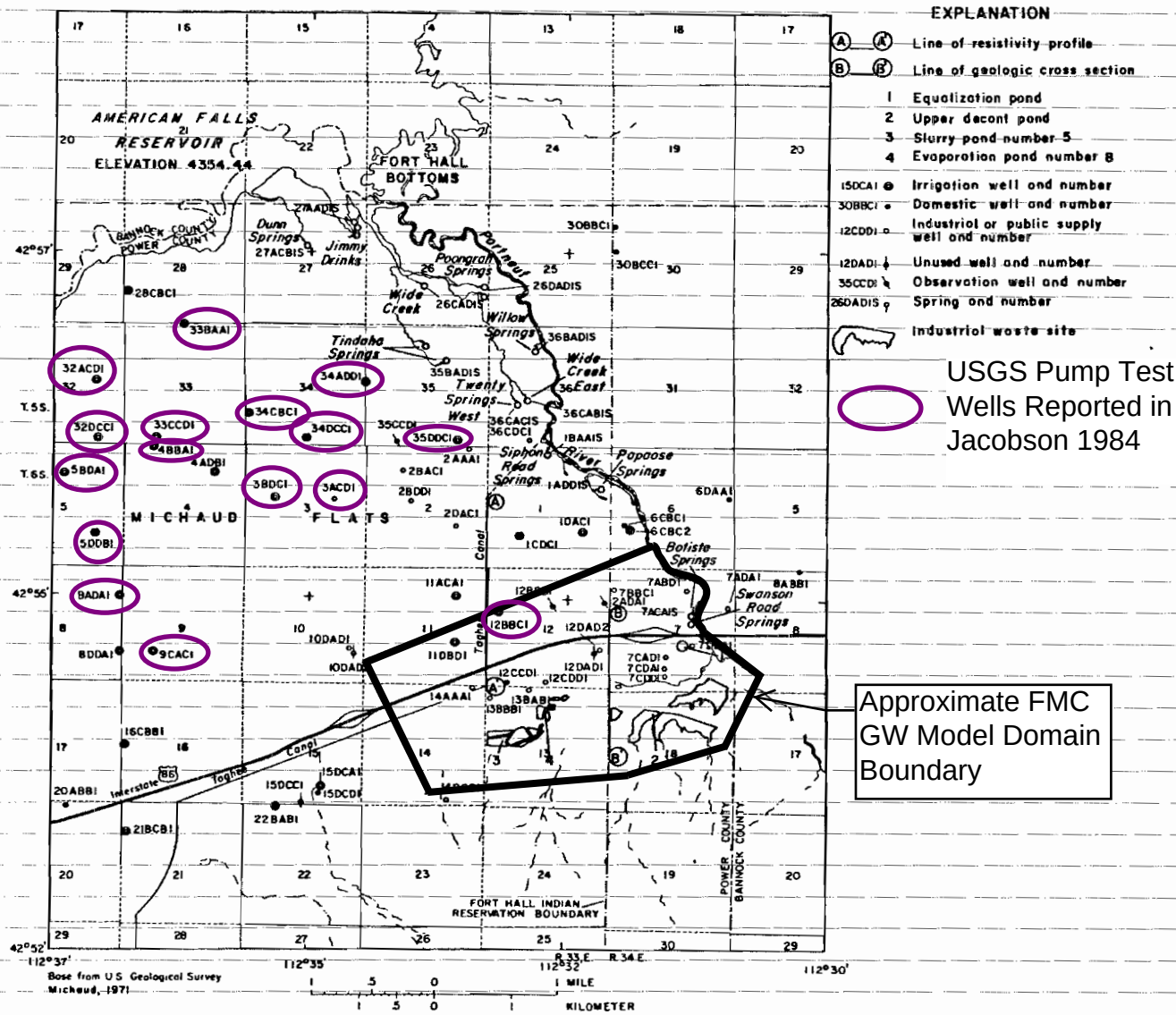


Figure 3.—Hydrologic data sites and electrical-resistivity profile lines.

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 4	524

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
OFF SITE	N 455,307.0 E 560,768.0	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
6-14-94	6-14-94	Layne Environmental	AP-1000	10"	120.0	2.0	122.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/na	0	0	4399.92	4397.4	20.0/4377.4 /	120.0'/4277.4'

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
na	4 in / 59 ft	C. Obi

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4397.4				0 - 8 ft. **GRAVELLY SILT (ML):** Moderate yellowishbrown (10 YR 7/4); 20% subangular to rounded gravel to 3 inches; 0-20% fine to coarse grained sand; soft, dry.	Borehole drilled with dual-wall percussion-hammer drill rig. Cuttings expelled from boring using reverse-air circulation. Soil descriptions based on visual observations of cuttings following the Unified Soil Classification System (USCS) and the Geological Society of America (GSA) Rock Color Chart.
								4389.4	5			8 - 112 ft. **SILTY GRAVEL (GM):** Moderate yellowish brown (10 YR 7/4); relatively uniform deposit of multicolored angular fragments to rounded cobbles to 6 inches; 10-20% fine to coarse grained sand; 20-30% silt; loose, dry.	
									10				
									15				
									20			Wet below 20 ft., abundant muddy water.	
									25				
									30				

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
OFF SITE	7-11-94	524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 4	524

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6" / % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								40				-
								45				
								50				
								55				
								60				
								65				
								70				

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: OFF SITE

Last Update: 7-11-94

HOLE NO. 524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	3 OF 4	524

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 4" % CORE RECOVERY	WATER PRESSURE TESTS LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								80				
								85				
								90				
								95				
								100				
								105				
								110				
							4285.4				112 - 120 ft. **CLAY (CH):** Grayish orange pink (5 YR 7/2) to moderate brown (5 YR 4/4); 0-20% fine to coarse grained sand; high plasticity; stiff, moist to wet.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: OFF SITE

Last Update: 7-11-94

HOLE NO. 524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	4 OF 4	524

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4277.4	120			120 - 121 ft. **FRACTURED BASALT:** Black vesicular basalt, hard, with calcite and mud-encrusted fractures.	
							4276.4				121 - 122 **BASALT:** Black vesicular basalt, very hard.	
							4275.4				TOTAL DEPTH: 122 FT.	
												Borehole 524 was allowed to cave from 122 to 59 ft then completed as monitoring well 524 on 6-14-94 using 4" Sch 40 PVC and screened between depths of 48.5 to 58.5 ft. See Well construction diagram for completion details.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: **OFF SITE**

Last Update: 7-11-94

HOLE NO. 524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 1	525

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
OFF SITE	N 455,296.9 E 560,772.1	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
6-15-94	6-15-94	Layne Environmental	AP-1000	10"	28.5	0.0	28.5

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/na	0	1	4399.61	4397.1	15.0/4382.1 /	na/na

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lb / 30 in	4 in / 28.3 ft	C. Obi

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4397.1				0 - 4 ft **GRAVELLY SILT (ML):** Moderate yellowish brown (10 YR 7/4); 20% subangular to rounded gravel to 3 inches; 0-20% fine to coarse grained sand; soft, dry.	Borehole drilled with dual-wall percussion-hammer drill rig. Cuttings expelled from boring using reverse-air circulation.
							4393.1				4 - 28.5 ft. **SILTY GRAVEL (GM):** Moderate yellowish brown (10 YR 7/4); angular to rounded multicolored gravel to 6 inches; 10-20% fine to coarse grained sand; 20-30% silt; loose, dry.	Soil descriptions based on visual observations of cuttings following the Unified Soil Classification System (USCS) and the Geological Society of America (GSA) Rock Color Chart.
								5				
								10				
SS	1.5	0.4	15-25-32					15			Wet below 15 ft., abundant muddy water.	
								20				
								25				
							4368.6				TOTAL DEPTH: 28.5 FT.	Borehole 525 completed as monitoring well 525 on 6-15-94 using 4" Sch 40 PVC and screened between depths of 17.8 and 27.8 ft. See well construction diagram for completion details.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
OFF SITE	7-11-94	525

Rob Hartman

From: Rob Hartman
Sent: Friday, September 11, 2009 11:00 AM
To: Lynch.Kira@epamail.epa.gov; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; Fisher.Carla@epa.gov; Ross.Randall@epa.gov; mbeljin@cinci.rr.com
Cc: Barbara Ritchie; Marc Bowman; Douglas Oliver Jr.; Zachary Brown; 'Prouty, Alan L'; Andy Koulermos
Subject: Summary of September 3, 2009 FMC GW Model Conference Call

This email summarizes the September 3, 2009 teleconference discussion regarding FMC's calibrated groundwater flow model and preliminary groundwater alternative simulations.

Teleconference participants:

EPA Kira Lynch, Bernie Zavala, Randall Ross, Milovan Beljin
FMC/MWH Barbara Ritchie, Doug Oliver, Zachary Brown, Rob Hartman

Rob Hartman reviewed the objectives of the call:

1. Discuss any additional comments / issues with the calibrated groundwater flow model,
2. Discuss any additional / follow-up comments on the preliminary groundwater alternatives simulations (particle track figures) discussed during the August 18 meeting,
3. Finalize schedule for September 21 meeting on the calibrated groundwater transport model and refined groundwater alternatives simulations.

The EPA participants and FMC/MWH participants confirmed their availability for the meeting on September 21 in Pocatello and set the time at 2:00 MDT. The meeting will also be conducted as a webcast meeting. FMC/MWH will make arrangements for the meeting location and webcast platform and circulate details prior to the meeting. Per Milovan Beljin's suggestion, MWH will plan a "test webcast" prior to the meeting to confirm accessibility for participants.

Prior to beginning discussion on the calibrated groundwater flow model and follow-up materials from the August 18, 2009 materials, Rob Hartman reviewed the project timeline beginning with the May 21, 2009 meeting (presentation of conceptual SFS GW alternatives and overview of the GW model to support development and comparative analysis of alternatives), July 1 meeting (review of the preliminary calibrated GW flow model) and August 18 meeting (review of calibrated flow model and preliminary transport model and simulated alternative capture zones). Following this summary, EPA provided follow-up comments / observations on the flow model as follows:

Bernie Zavala stated that his question on the high hydraulic conductivities assigned to Layer 2 in the area of the domain along the Portneuf River and springs has not been completely addressed; however, he is satisfied the flow model is adequately calibrated to proceed with the transport model and alternative simulations. Bernie noted that the follow-up information related to the USGS pump tests and wells 524/525 boring logs provided a reasonable justification for the lower K area north of Batiste Spring, but additional data in the area south of Batiste Spring and near the river that is expected from installation of the additional Simplot wells in this area of the site should be considered for potential future refinement of the flow model.

Randall Ross began by stating there are no "show stoppers" in the flow model, but also questioned the high hydraulic conductivities assigned to Layer 2 in the area of the domain along the Portneuf River and springs (also noting potential refinement as additional Simplot data become available in this area of the site). Randall also raised a question regarding potential effects from agricultural irrigation recharge in the areas to the north and west of the FMC Plant Site on simulation of the remedial alternatives.

Milovan Beljin also raised a question regarding agricultural irrigation recharge in the areas to the north and west of the FMC Plant Site and potential recharge from the Taghee (irrigation) Canal. Rob Hartman described the multiple lines of evidence (seasonal use, standing water in the fall after head-gate closed and lack of observed seasonal water level changes in wells near the canal) that indicate the canal is not a significant source of recharge compared to the overall water budget as cited by Bechtel in the EMF RI groundwater model report. Milovan stated that the model report should document the appropriateness of the assumptions for these areas in the calibrated flow model and that the sensitivity analysis should address these remaining questions.

On the topic of the preliminary groundwater alternatives simulations, Bernie Zavala reiterated the comment from the August 18 meeting regarding his concern of dewatering the shallow aquifer zone / sustainable yield of a 2 extraction well configuration for preliminary Alternative 2. Rob Hartman acknowledged the concern based on variability of observed yields from Simplot's extraction wells and stated that MWH will be refining the well configuration for Alternative 2 to simulate 3 or possibly 4 wells. These refined alternative simulations will be presented during the September 21 meeting.

Barbara Ritchie asked for clarification regarding the timing of the proposed new Simplot wells in the area near the river/springs in the context of the comments regarding using data from the wells to potentially refine the FMC groundwater model, particularly given the current schedule to complete the FMC groundwater modeling and comparative simulations in the October 2009 timeframe. Kira Lynch restated EPA's position that the currently calibrated flow model is adequate for proceeding with evaluation of alternatives and future new data and potential refinements to the flow model could be used to support detailed remedial design of the groundwater alternative.

In summarizing the path forward, Rob Hartman confirmed MWH will proceed with transport modeling and will post GMS/MT3D files for the calibrated transport model on the ftp site on September 15, in advance of the September 21 meeting. MWH will route details on the September 21 meeting location and webcast during the week of September 14. The conference call then concluded.

Contact me should you have questions regarding this information. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Rob Hartman

From: Rob Hartman
Sent: Wednesday, September 16, 2009 2:21 PM
To: 'Lynch.Kira@epamail.epa.gov'; 'Zavala.Bernie@epamail.epa.gov'; 'Scott.Miller@deq.idaho.gov'; 'Doug Tanner'; 'Kelly Wright'; 'Susan Hansen'; 'Fisher.Carla@epa.gov'; 'Ross.Randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: 'Barbara Ritchie'; Marc Bowman; Douglas Oliver Jr.; Zachary Brown
Subject: September 21, 2009 FMC GW Modeling Meeting
Attachments: Draft Agenda for Sept 21 2009 FMC GW Model Meeting.docx

Transport Model Files Posted to MWH FTP Site

Per the August 18 meeting and follow-up September 3 conference call, the GMS-MODFLOW-MT3DMS files for the calibrated groundwater flow and transport model have been posted to the MWH ftp site under the folder "FMC Transport" in advance of our September 21 meeting.

The ftp site link is: ftp.mwhglobal.com
Username: slc1-FMC
Password: polonium

Instructions for accessing the Ftp site with Internet Explorer 5.0 or higher:

Open Browser and go to Ftp.mwhglobal.com
Go to File on your drop down menu and select "Login As" – the login menu may pop-up automatically if you have Explorer 7.0 or higher).
Enter "slc1-FMC" for the user name and "polonium" for the password
This will log you in and display the files that have been loaded onto the site,
Select the folder "**FMC Transport**" and open
Select the files you need, right click on one and use the "Copy To Folder" option on the popup menu to save files to your local computer (Explorer 7.0 or higher should allow 'drag and drop' copying to local computer).

Note that the flow model was further refined following the September 3 conference call to increase the recharge in the irrigated agricultural fields north of Interstate 86 in the northwest area of the model domain. The recharge was increased from 1.2 inches per year to 12 inches per year (10-fold increase). The flow field and calibration results did not change significantly but this refinement was considered appropriate based on EPA input. The calibration results for the flow model with this refinement will be presented during the September 21 meeting.

Draft Agenda for September 21, 2009 Meeting

A draft Agenda for the September 21 meeting is provided in the attachment to this message. Note that the meeting is scheduled to begin at 2:00 p.m. MDT and will be held at the Holiday Inn, Executive Board Room in Pocatello.

Information for Webcast Meeting

MWH is currently transitioning our audio/web and video conferencing service provider, but still expect to be able to conduct the meeting as a webcast. However, new accounts will not be set up until Thursday or Friday this week so I do not have the ability to set up a "test" or provide details (Cast ID / Passcode) as yet. I will forward details regarding a possible test for Friday and/or details for the webcast associated with the September 21 meeting when available. In the meantime, the general system requirements to participate in the webcast are:

- Current Operating System / Platform:

    - Microsoft Windows 98/2000/XP/Vista or Server 2003 System
    - Internet Explorer 6, Netscape 7.0, Firefox 1.0 or higher browser version
    - Mac OS X with Firefox or Apple Safari 1.1
    - Linux, Unix or Solaris with Netscape 7.0+, Mozilla 1.0+
- 56Kbps+ Internet connection
- 128Kbps+ Internet connection is recommended for large document sharing
- Minimum CPU: ~300Mhz
- Cookies and Scripting enabled in browser

Contact me should you have questions regarding this information. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Draft Agenda for Agency-FMC Meeting on FMC Groundwater Modeling
September 21, 2009, Pocatello, ID
Holiday Inn – Executive Board Room
2:00 – 5:00 p.m. MDT

2:00	Introductions
2:10	Review Groundwater Flow Model refinement and final calibration results
2:30	Calibrated Groundwater Transport Model
	• Review parameter inputs (groundwater data, plume maps and contaminant transport parameters)
	• Calibration / plume matching
	• Sensitivity analysis
3:15	Preliminary predictive simulations
	• Review assumptions for non-FMC source/sinks
	• Review results for refined groundwater remedial alternatives
4:00	Meeting recap and next steps

FMC
Supplemental Feasibility Study
Groundwater Modeling Update

September 21, 2009
Pocatello, Idaho

MWH

BUILDING A BETTER WORLD

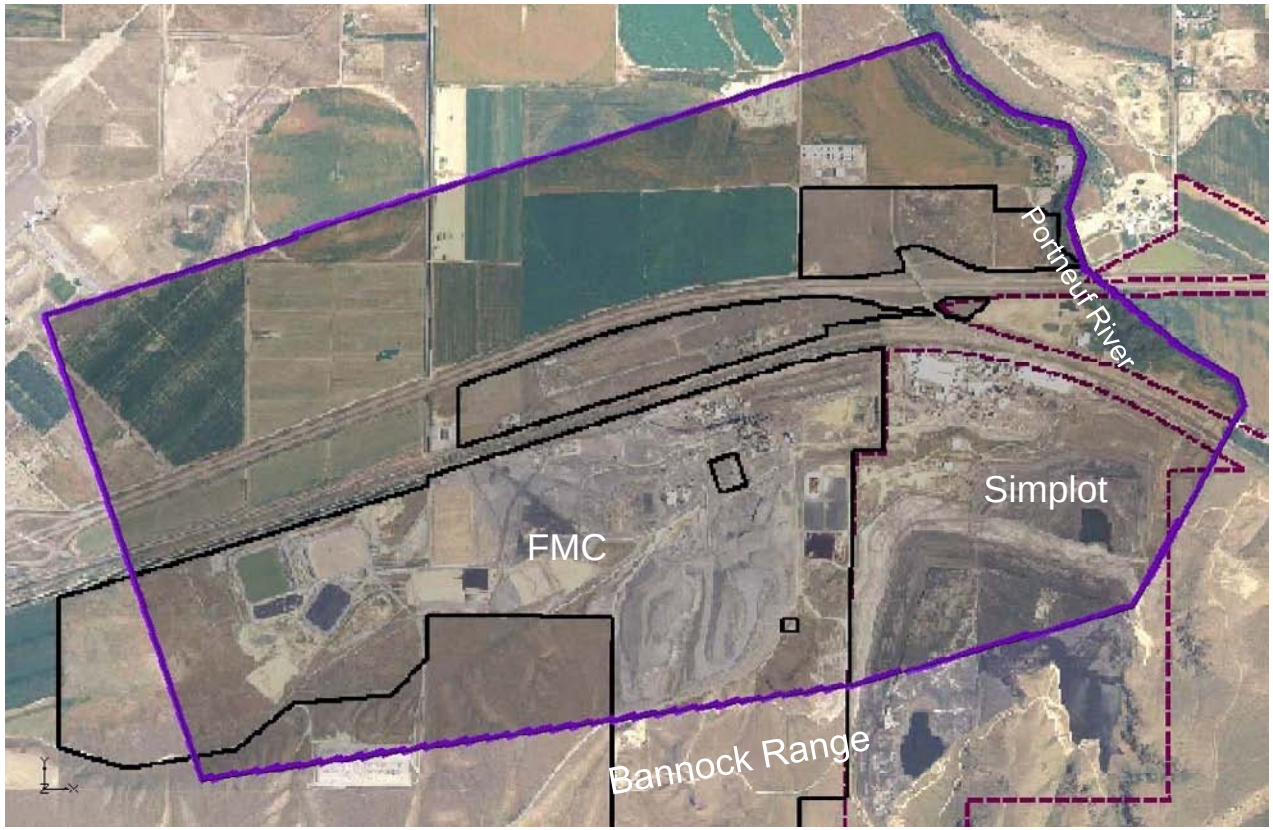
Modeling Objectives

- Development of a tool that can support the Supplemental Feasibility Study and compare remedial alternatives for the FMC Plant Operable Unit of the Eastern Michaud Flats Superfund Site
- Groundwater flow model was developed to provide the underlying flow regime for contaminant fate and transport simulations
- Contaminant transport calibration was performed to improve estimates of transport parameters for predictive simulations

Flow Model Review

Domain approximately 15,500 by 9,000 feet – 2,862 acres

50 ft by 50 ft cells (50,463 per layer – total 201,852 cells)



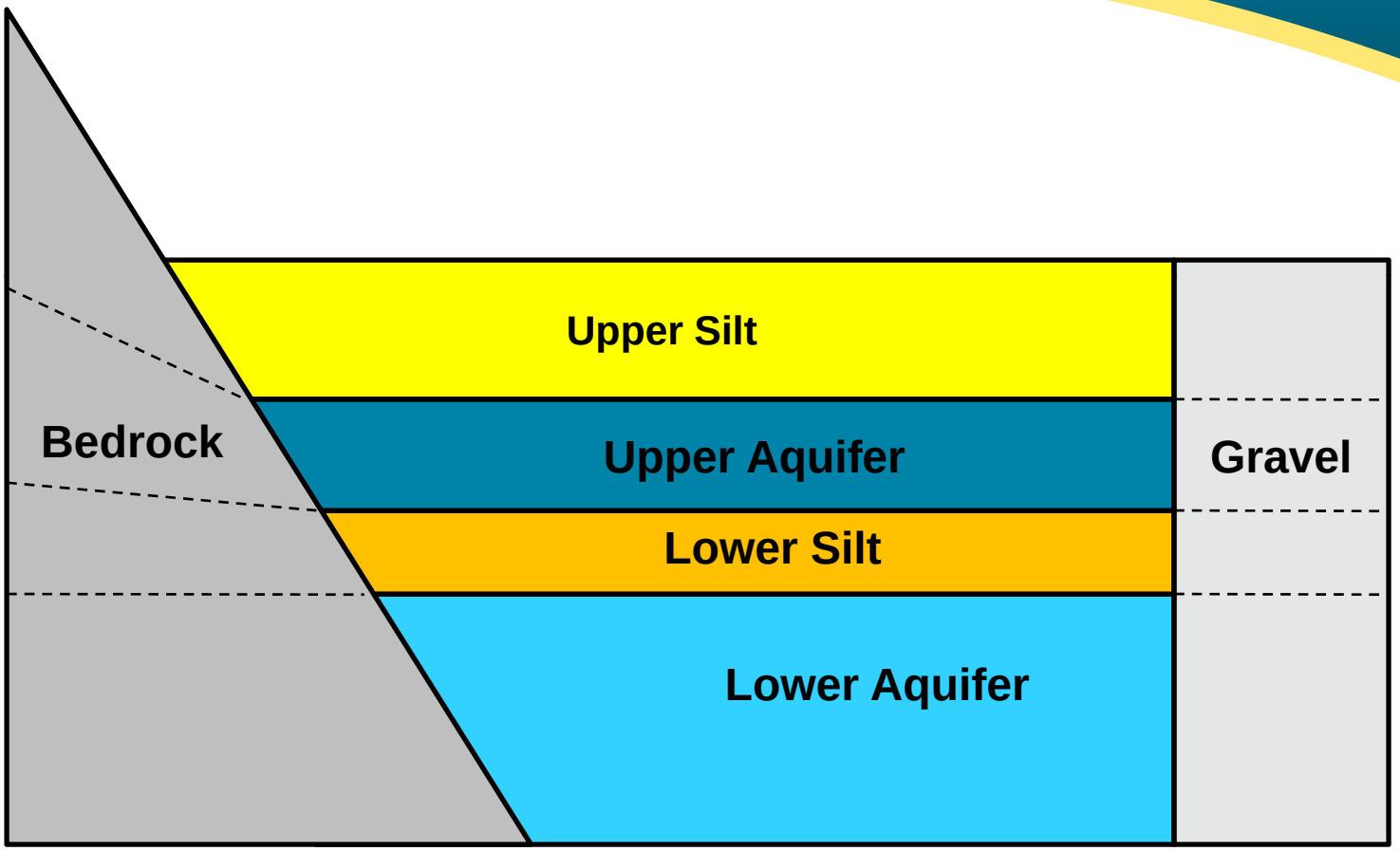
Layering

In general, the model layering scheme is based upon the major hydrogeologic units identified in the RI:

- Layer 1 = Upper Silt/volcanic bedrock/gravel
- Layer 2 = Upper Aquifer Zone/volcanic bedrock/gravel
- Layer 3 = Lower Silt/volcanic bedrock/gravel
- Layer 4 = Lower Aquifer Zone/volcanic bedrock/gravel

Clear distinctions between units are not always present and the vertical discretization is not necessarily based on stratigraphy near the Bannock Range and the Portneuf River

Layering


Upper Silt
Bedrock
Upper Aquifer
Gravel
Lower Silt
Lower Aquifer

Changes to Flow Model Following September 3rd Conference Call

- As per EPA suggestion, additional recharge assigned to northern agricultural areas (12 in/yr)
- Evaluated hydraulic conductivity distribution in northeast region of domain. No changes to hydraulic conductivity field were made in final calibrated model.

Calibration Statistics for Final Flow Model

Range of errors = -6.1 ft to +4.2 ft

Average error = -0.4 ft

Absolute average error = 1.1 ft

Root mean squared error = 1.5 ft

Normalized root mean squared error = <1%

Contaminant Transport Model

Purpose and Objectives

- To simulate transport of the primary contaminant and indicator parameters
- Support the SFS and remedial alternatives development
- To evaluate and optimize remedial alternatives

Contaminants Simulated

- Arsenic
  - Primary risk driving groundwater COC
- Total Phosphorus/Orthophosphate
  - Primary (groundwater to) surface water COC
- Potassium
  - Key indicator of FMC source areas

Transport Model Calibration

Plume Matching Process

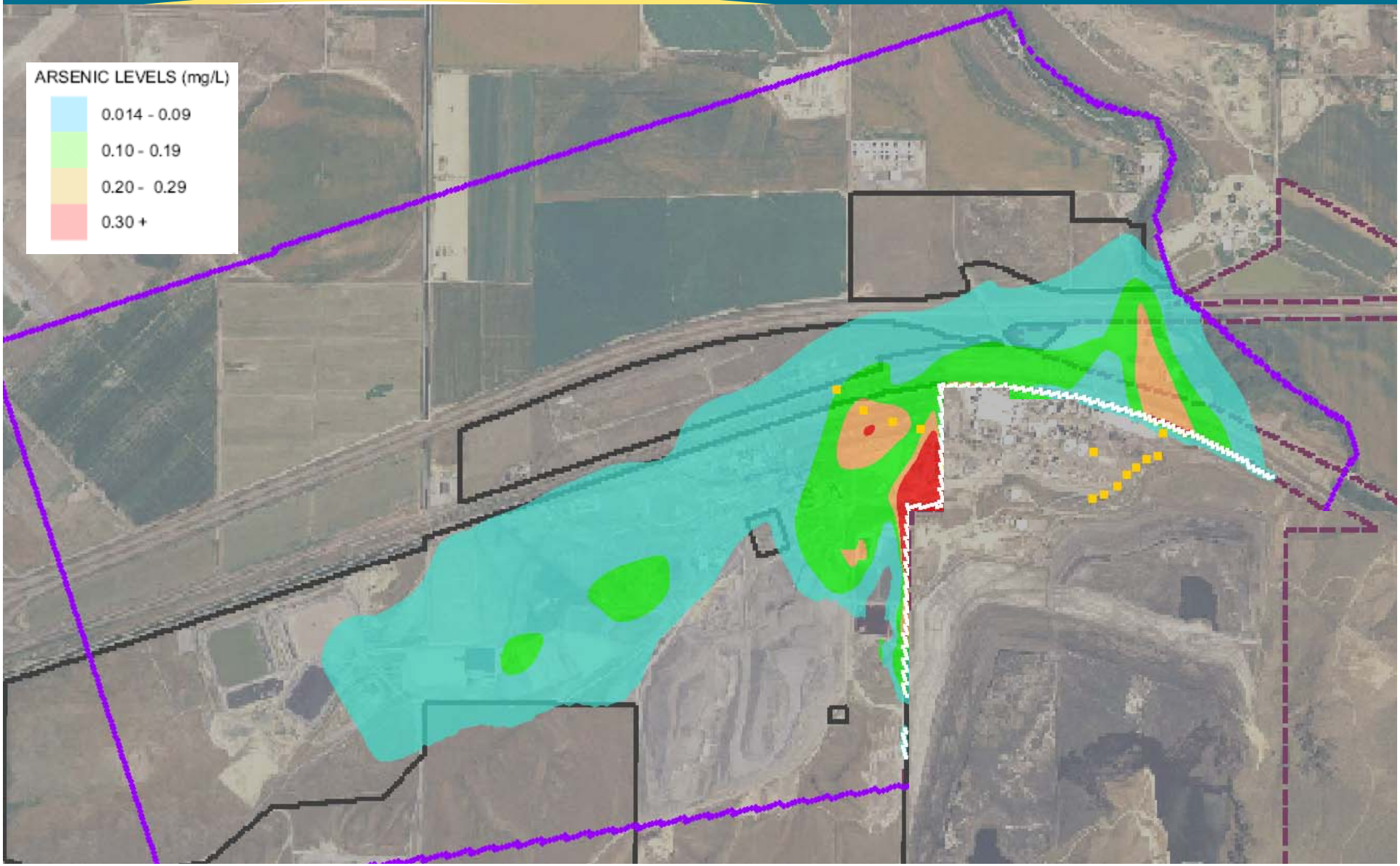
- 1994 plumes used as initial conditions
- Ongoing sources assumed at Pond 8S, Old Phossy Ponds 3E-6E (beneath Pond 15S area), and Simplot
- Plume matching process involved adjusting sorption/retardation, dispersivity, porosity, and source strength
- Simulated 2008 contaminant plumes were compared to plume maps generated with measured concentrations (average 2006-2008 data)

Causes of Differences Between Observed and Simulated Plumes

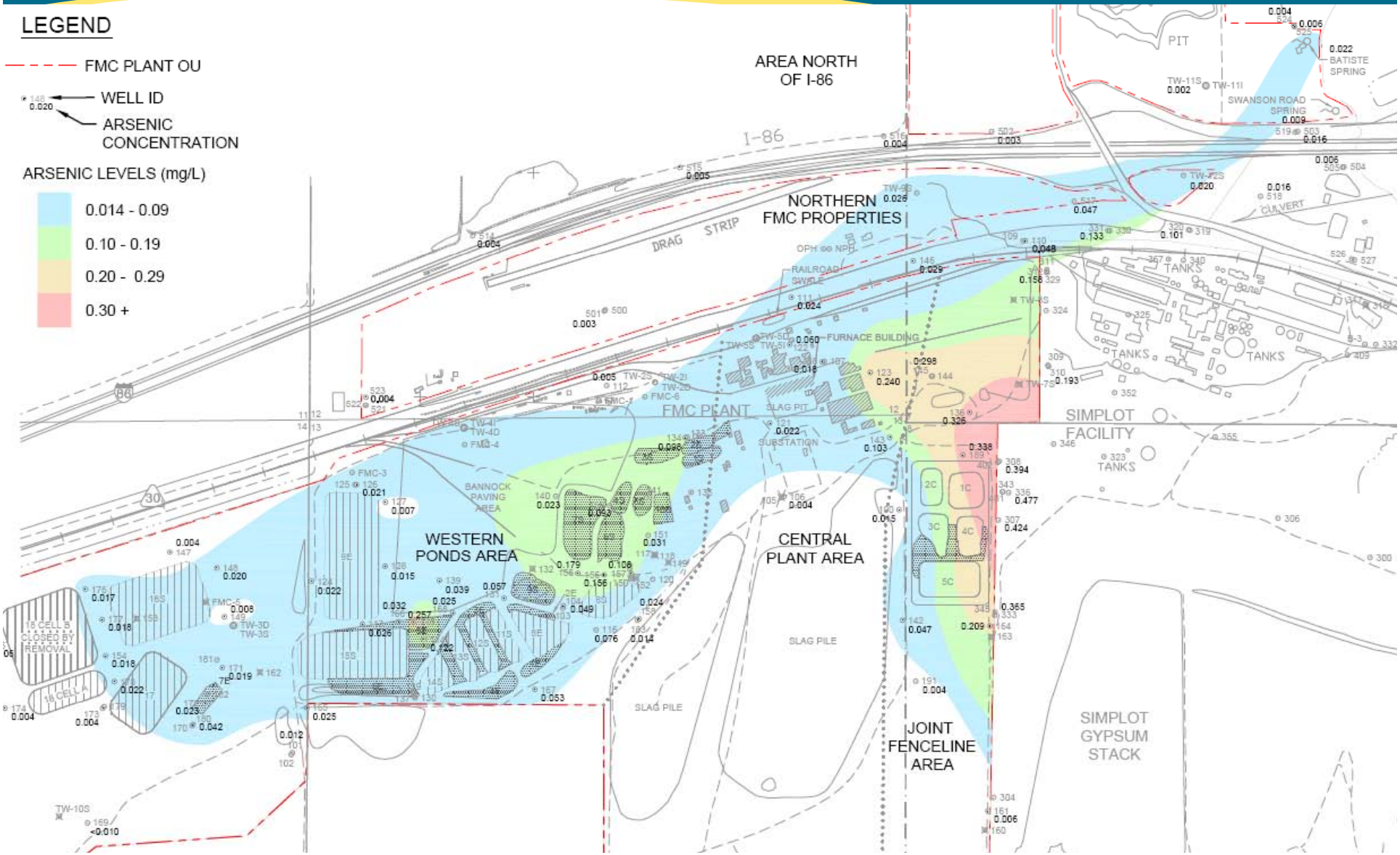
- Simplot gypsum stack input concentrations assumed constant at 1994 levels
- Simplot east overflow pond input concentrations assumed constant at 1994 levels
- No 1994 contaminant data were available from west end of FMC site (Pond 17 & 18 wells installed post-RI)
- These assumptions, simplifications, and data gaps lead to differences between 2008 observed and simulated plumes

Model-Predicted Arsenic Plume (2008)

Preliminary – Subject to Change

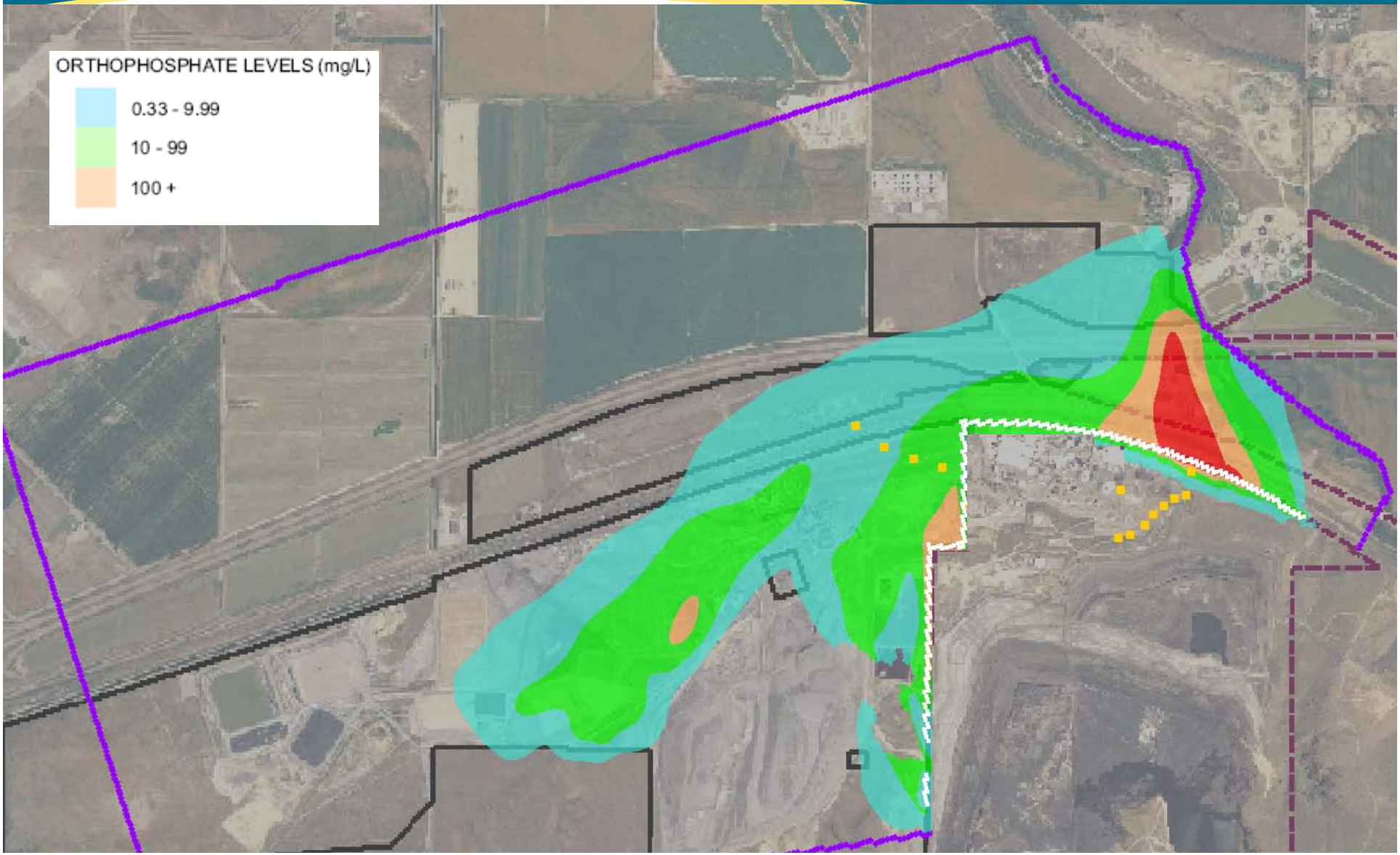


Observed Arsenic Plume (2008)

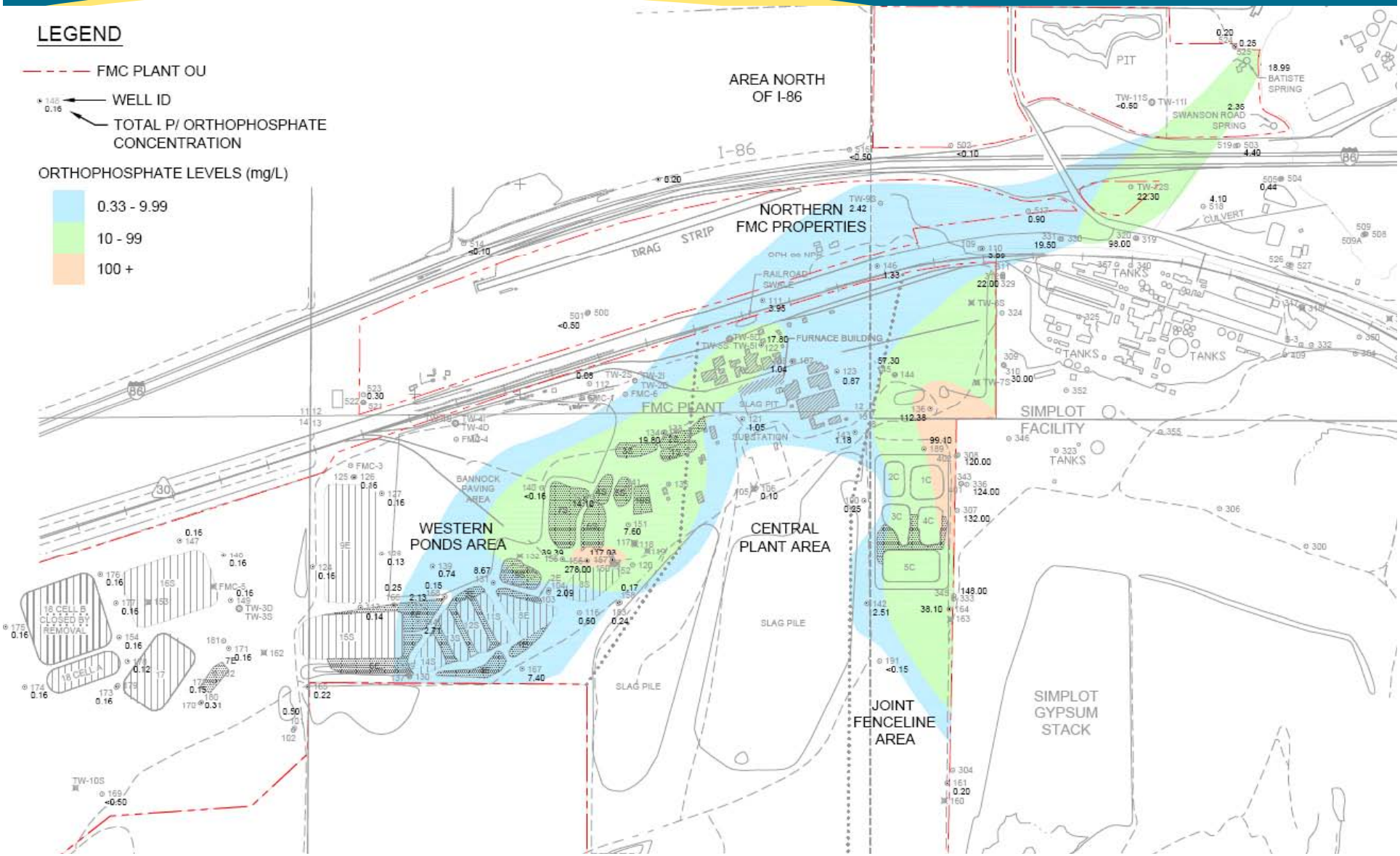


Model-Predicted Orthophosphate Plume (2008)

Preliminary – Subject to Change

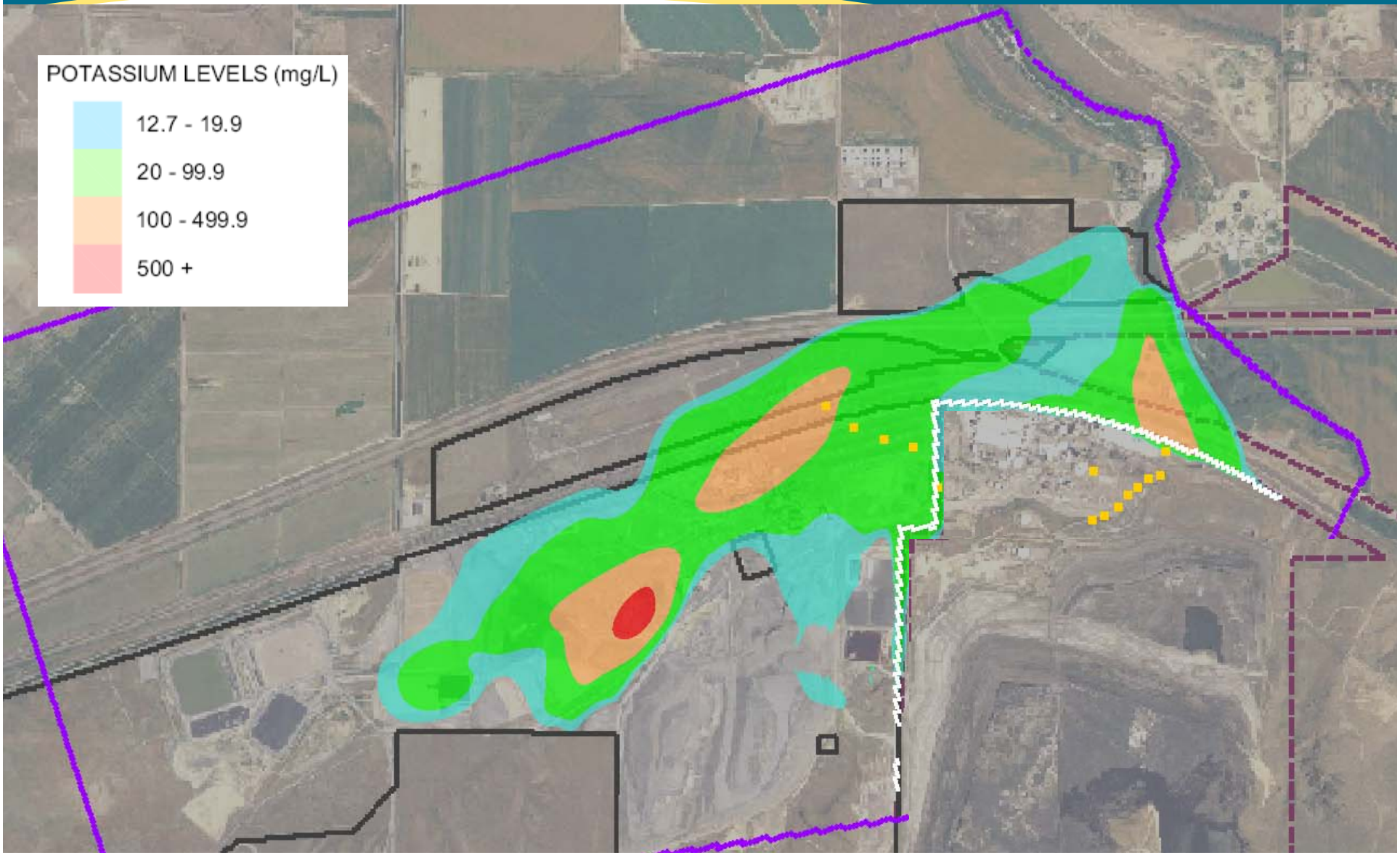


Observed Orthophosphate Plume (2008)

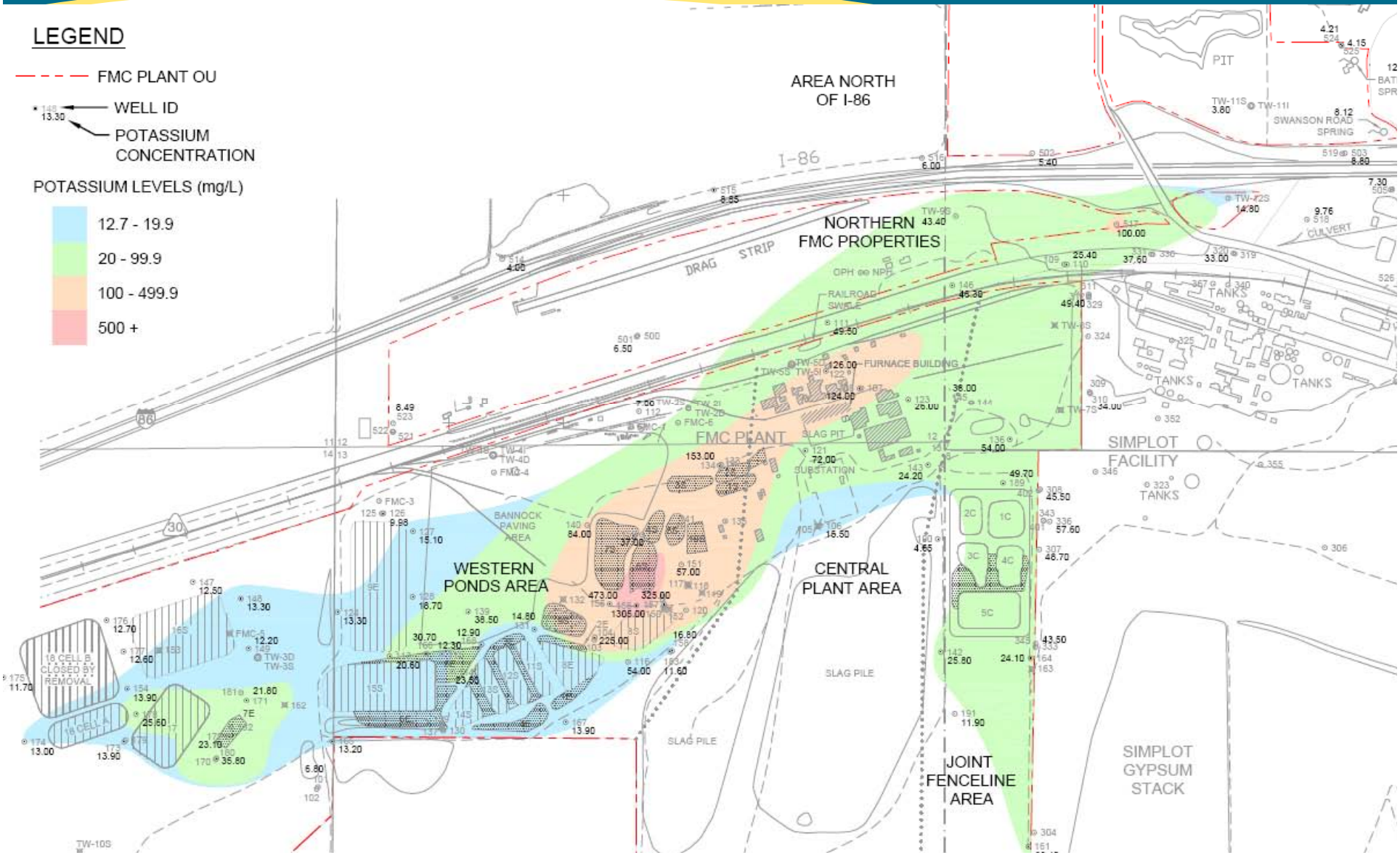


Model-Predicted Potassium Plume (2008)

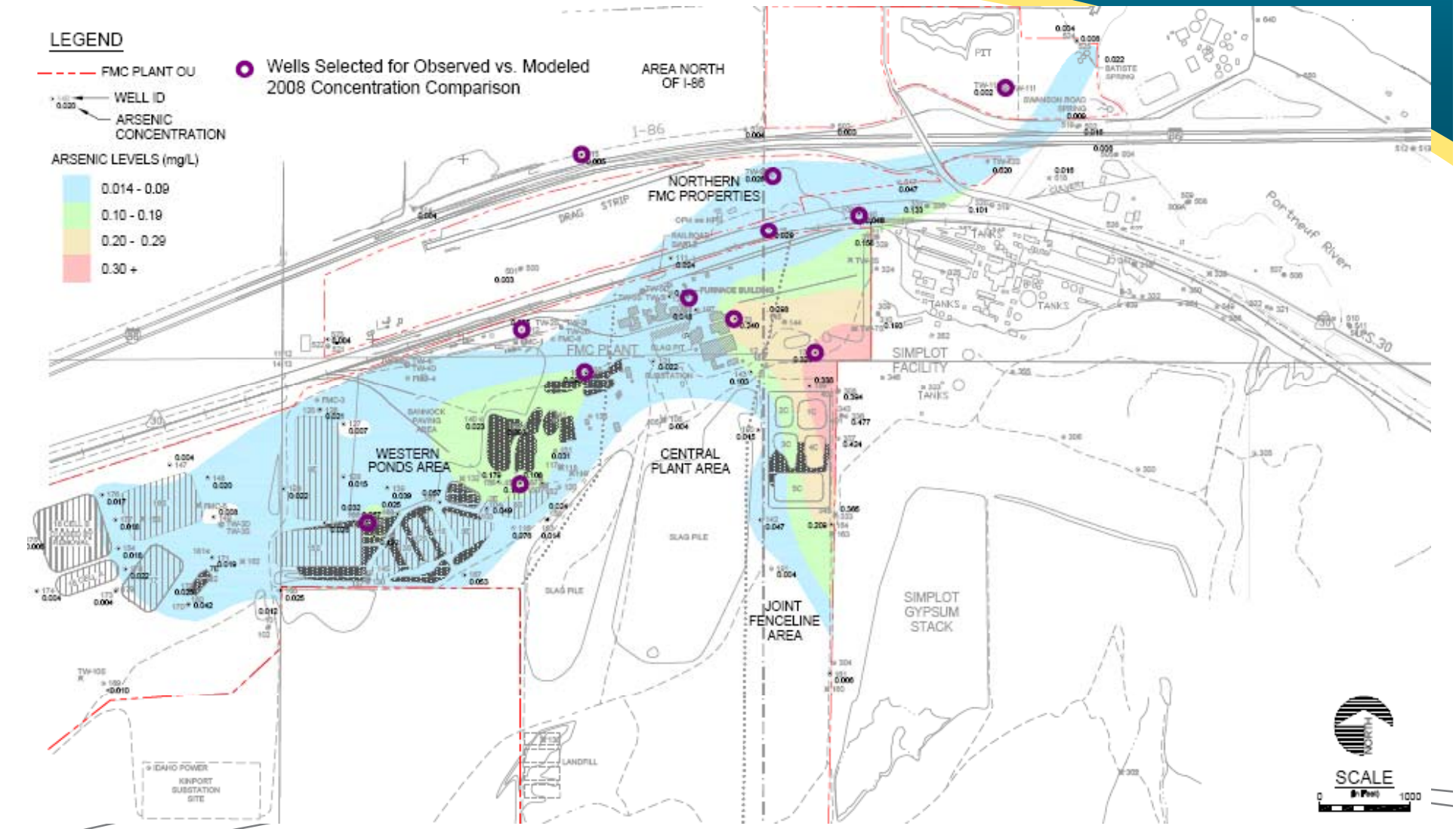
Preliminary – Subject to Change



Observed Potassium Plume (2008)



Wells Selected for Observed vs. Modeled 2008 Concentration Comparison



2008 Concentrations (mg/l) at Selected Observation Wells

Station ID	Observed Arsenic	Simulated Arsenic	Observed Orthophosphate / Total P	Simulated Orthophosphate / Total P	Observed Potassium	Simulated Potassium
WELL-115	0.26	0.14	2	4	12	13
WELL-156	0.16	0.12	278	330	1305	1045
WELL-134	0.10	0.07	20	46	153	145
WELL-122	0.06	0.06	18	13	126	130
WELL-123	0.24	0.12	1	5	26	37
WELL-136	0.33	0.20	112	45	54	31
WELL-110	0.05	0.09	3	19	25	39
WELL-146	0.03	0.14	1	3	46	98
TW-9S	0.03	0.02	3	5	58	72
WELL-112	0.01	0.02	1	1	7	14
WELL-515	0.01	0.00	0	0	9	2
TW-11S	0.00	0.01	1	1	5	20

Concentrations in mg/L

Plume Matching Summary

- 2008 plume lengths and widths matched for arsenic, orthophosphate, and potassium
- 2008 distribution of contamination matched reasonably well on the FMC plant site
- Transport calibration was performed to improve estimates of transport parameters for predictive simulations
- Measured 2008 contaminant data will be imported for predictive simulation initial conditions

Calibrated Transport Parameters

Effective Porosity

- 35 percent

Longitudinal Dispersivity

- Initial Estimate of 55 feet based on plume length method: $\alpha_L = 0.82(\mathrm{Log}_{10}L)^{2.446}$ (Xu & Eckstein, 1995)
- Final calibrated value of 25 feet (transverse = 2.5 feet, vertical = 0.25 feet)

Sources

- Pond 8S (recharge rate = 2×10^{-5} inch/year)
  - 0.62 mg/l Arsenic, 3000 mg/l Potassium, 3700 mg/l Phosphate
- Pond 3E-6E (recharge rate = 2×10^{-5} inch/year)
  - 0.62 mg/l Arsenic

Final Transport Parameters

Sorption and Retardation

- Arsenic
  - K_d = 2.8 ml/g (literature range 1-29 ml/g)
  - R = 13
- Orthophosphate
  - K_d = 2.3 ml/g
  - R = 11
- Potassium
  - K_d = 2.8 ml/g (literature value 15 ml/g)
  - R = 13

Sensitivity Analysis Results

Transport parameters (sorption, dispersivity, porosity) were varied within reasonable ranges and the results were compared to the calibrated plumes:

- K_d x 5 = too little plume migration, very little change from initial conditions
- K_d / 5 = too much plume migration and dilution of higher concentration areas
- D x 10 = more disperse plumes, poor simulation of higher concentration areas
- D / 10 = only slightly less disperse plumes
- n + 10% = no significant change from the calibrated plumes
- n – 10% = no significant change from the calibrated plumes

Overall, the transport model was highly sensitive to changes in the sorption coefficients, and much less sensitive to the other transport parameters

Predictive Simulations of GW Alternatives

GW Alternative 1

- Source Controls (i.e., Soil Remedial Actions)
- Institutional Controls (Prevent use/ingestion of site-impacted groundwater)
- Long-term groundwater monitoring

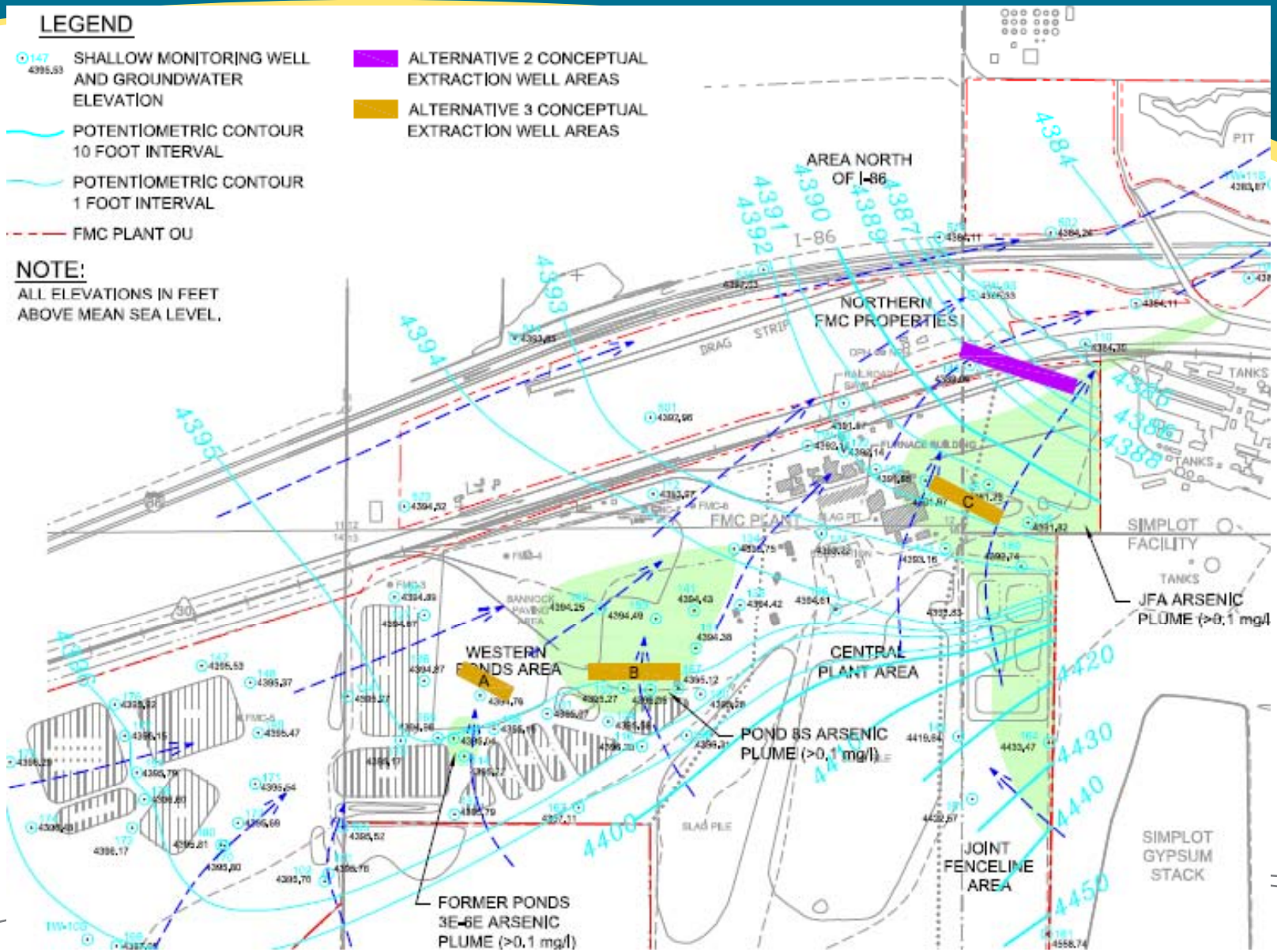
GW Alternative 2

- Alternative 1 components
- Groundwater extraction for hydraulic containment at plant boundary
- Treatment and/or use of extracted groundwater

GW Alternative 3

- Alternative 1 components
- Groundwater extraction at identified source areas
- Treatment and/or use of extracted groundwater

Predictive Simulations of GW Alternatives



Predictive Simulation Assumptions

- Initial conditions for contaminant distribution based on observed 2008 data

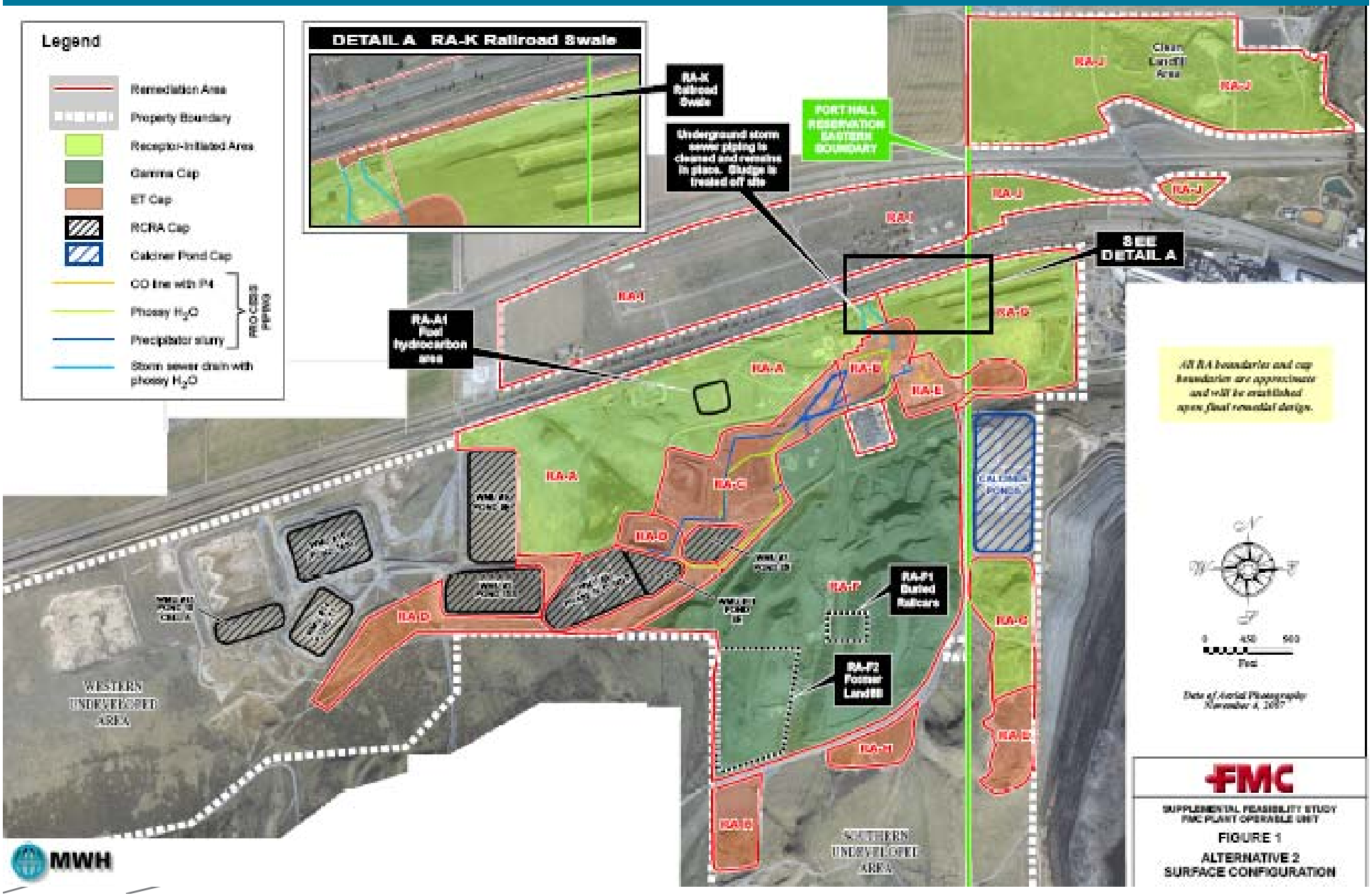
- Simplot
  - recharge from gyp stack = ~900 gpm (2009-2015)
  - recharge from gyp stack = 0 (after 2015)
  - pumping assumed constant based on 2008 rates
  - specified concentration at fence line based on 2008 data

- 2 steady-state flow models (2009-2015, 2015+)

Predictive Simulation Assumptions (continued)

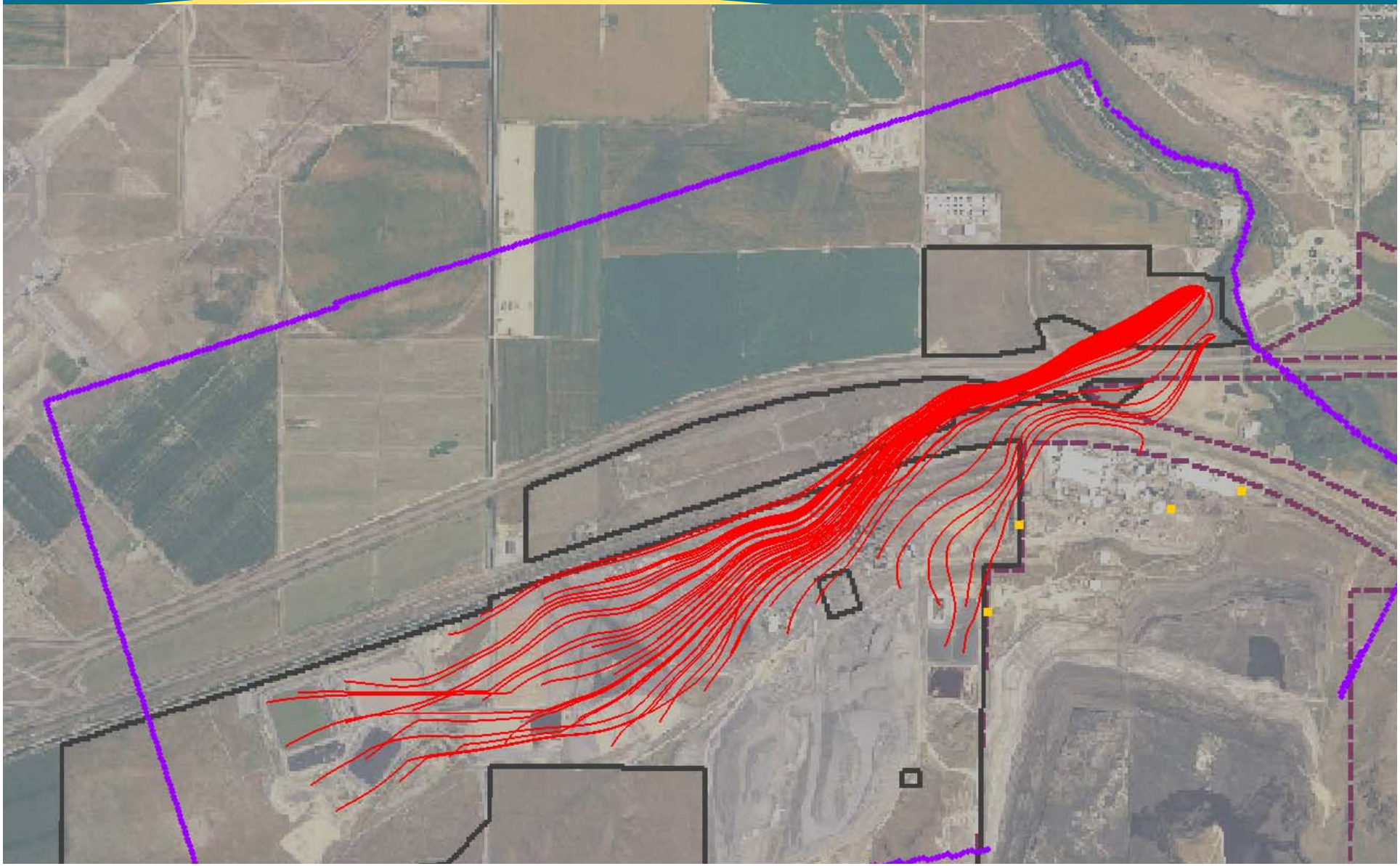
- Existing caps incorporated in calibrated flow model
  - RCRA and Calciner Pond Caps assigned infiltration rate = 2×10^{-5} inch/year
- SFS Assembled Soil Alternatives
  - Soil Alternative 2 ET Cap RAs assigned infiltration rate = 0.05 inch/year
  - Gamma Cover = natural infiltration rate = 1.2 inch/year
  - No changes in recharge would result from soil alternatives that include excavation and removal

Soil Alternative 2



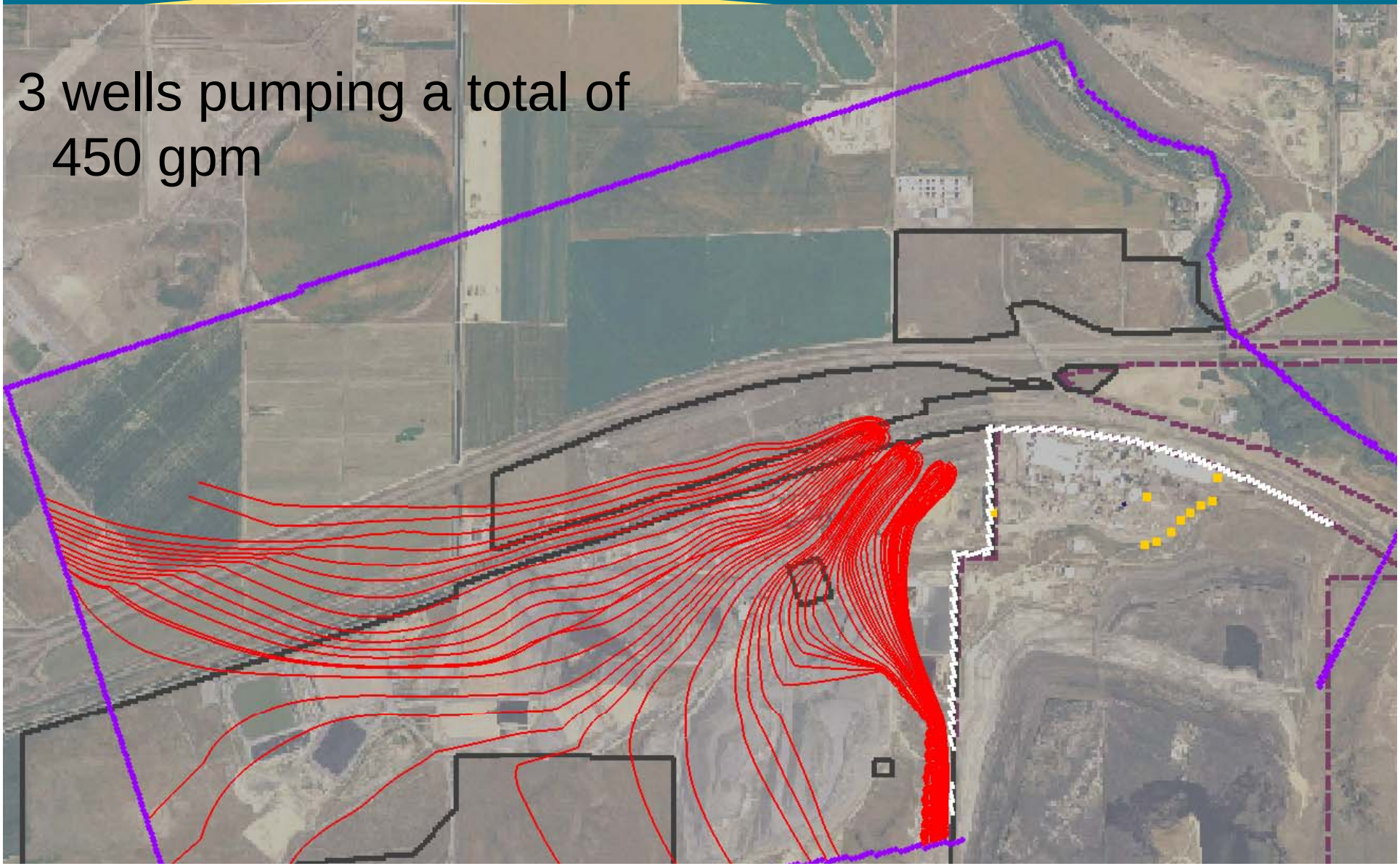
GW Alternative 1: Forward Particle Tracking

Preliminary – Subject to Change



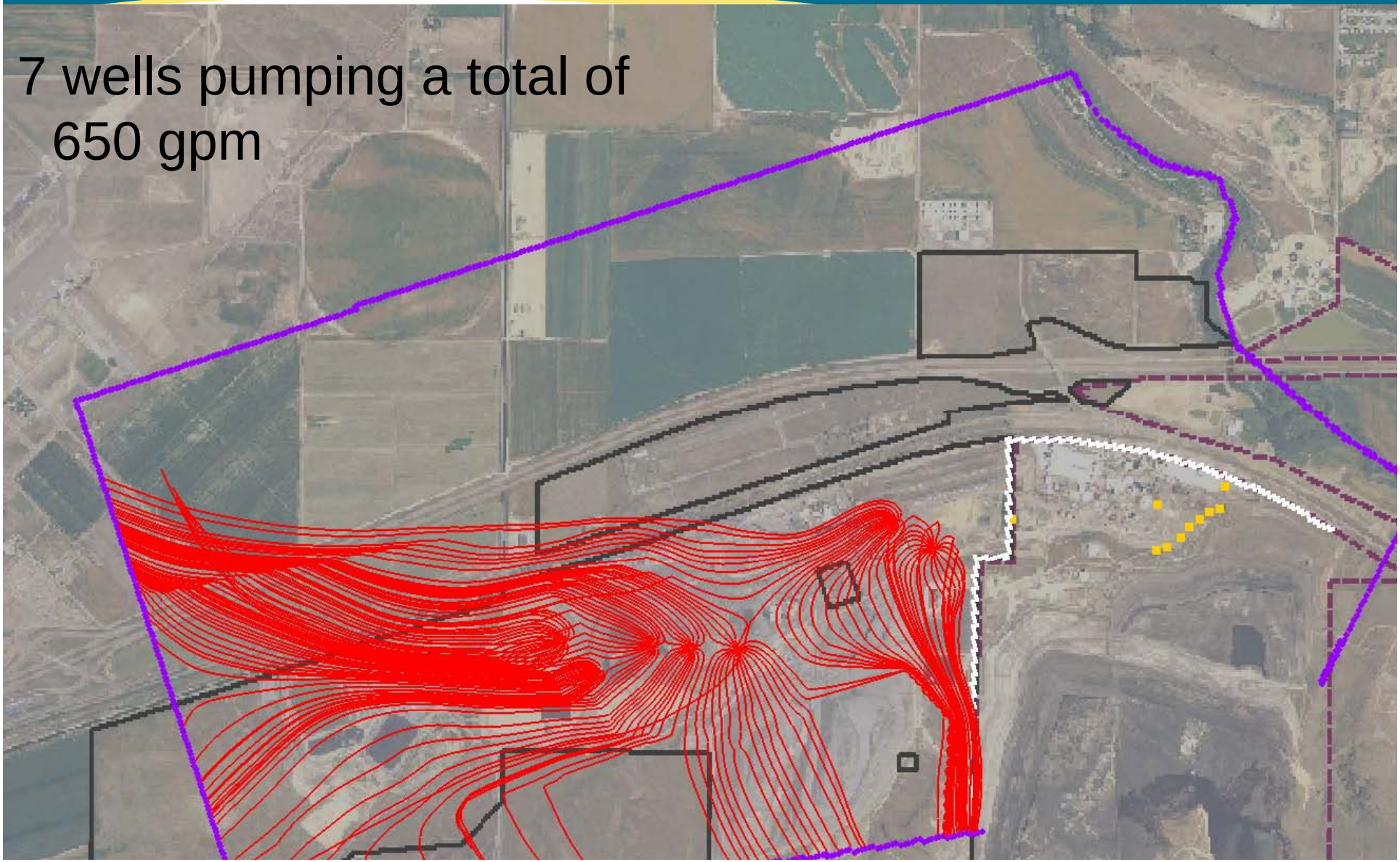
GW Alternative 2: Capture Zones

Preliminary – Subject to Change



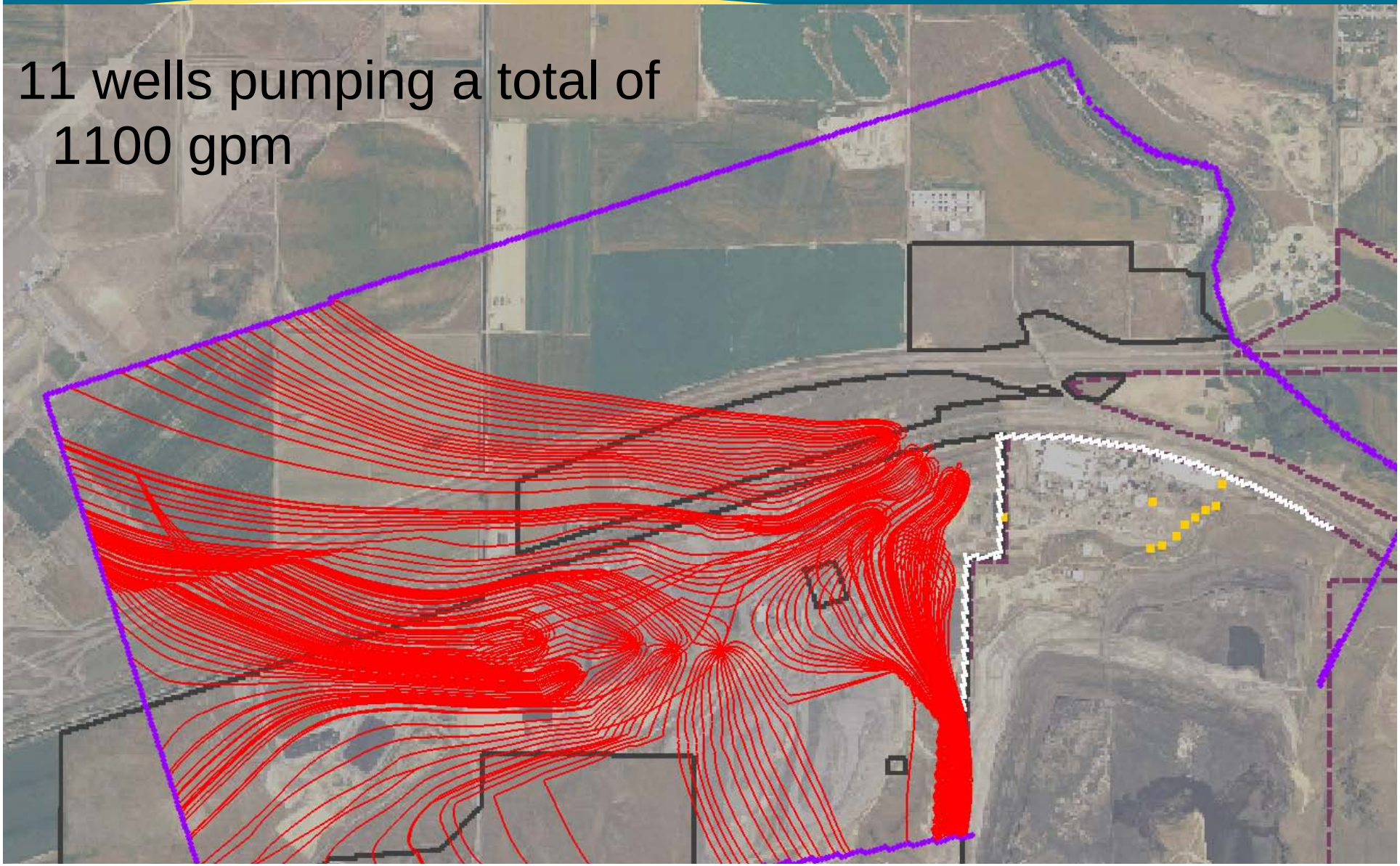
GW Alternative 3: Capture Zones

Preliminary – Subject to Change



Combination of GW Alternatives 2 and 3

Preliminary – Subject to Change



Simulated Flow Rates and Observed 2008 Concentrations

Alternative	Zone	Modeled Extraction Rate (gpm)	Observed Avg Arsenic (mg/l)	Observed Avg Total P (mg/l)
1		0	NA	NA
2		450	0.035	2.5
3	A	70	0.14	1.9
	B	210	0.15	145
	C	370	0.21	20
	Total	650		
2+3	2	450	0.035	2.5
	3A	70	0.14	1.9
	3B	210	0.15	145
	3C	370	0.21	20
	Total	1100		

Report Outline

Introduction

- Study objectives

Site Conceptual Model

- Geology and hydrogeology

Methodology

- Groundwater flow model construction
- Contaminant transport model construction

Results

- Flow model calibration results
- Transport model calibration results
- Groundwater remedial alternatives simulations
- Sensitivity analysis
- Assumptions and limitations

Summary and Conclusions

Path Forward

- Agreement on contaminant transport model calibration
- Agreement on assumptions for GW alternatives
- Agreement on assumptions for predictive simulations
- Complete predictive simulations
- Hold meeting mid October to review predictive results
- Prepare model report (presented as appendix to SFS report)

Rob Hartman

From: Zavala.Bernie@epamail.epa.gov
Sent: Tuesday, September 29, 2009 12:26 PM
To: Rob Hartman
Cc: Andy Koulermos; 'Prouty, Alan L'; Barbara Ritchie; Fisher.Carla@epa.gov; Douglas Oliver Jr.; Doug Tanner; Lynch.Kira@epamail.epa.gov; Kelly Wright; Marc Bowman; mbeljin@cinci.rr.com; Ross.Randall@epa.gov; Scott.Miller@deq.idaho.gov; Susan Hansen; Zachary Brown
Subject: Re: September 21, 2009 FMC Groundwater Model Meeting Presentation
Attachments: FMC SFS GW Model Meeting 21Sept09 Presentation.pdf

To All:

At the end of the GW modeling update meeting in Pocatello on September 21, we tentatively set up a follow call for Wednesday Sept. 30th. EPA wanted to discuss internally the slides that was presented before agreeing on the contaminant transport model calibration, and the assumptions for both GW alternatives and predictive simulations. We did have some questions and I will discuss those with Rob when he is available but those questions shouldn't stop MWH from moving forward with the predictive simulations.

Based on the above we don't feel that a call is needed for this Wednesday September 29th. I have spoken with Scott Miller, IDEQ and he agrees and we can discuss the results of the predictive simulation during the meeting in Boise in Mid October.

Rob, call me before Friday, October 2, I will not be in the Office on Friday.

Bernie
****
Bernie Zavala, Hydrogeologist
US EPA, Region 10
Office of Environmental Assessment
1200 6th Avenue, OEA-095
Seattle, Wa 98101
Phone: 206-553-1562; Fax: 206-553-0119
Zavala.Bernie@EPA.GOV
****

Rob Hartman
<Rob.J.Hartman@us.mwhglobal.com>

09/22/2009 02:39 PM

To
Kira Lynch/R10/USEPA/US@EPA, Bernie Zavala/R10/USEPA/US@EPA, "Scott.Miller@deq.idaho.gov" <Scott.Miller@deq.idaho.gov>, Doug Tanner <Douglas.Tanner@deq.idaho.gov>, Kelly Wright <kwright@shoshonebannocktribes.com>, Susan Hansen <susanh@ida.net>, Carla Fisher/R10/USEPA/US@EPA, Randall Ross/ADA/USEPA/US@EPA, "mbeljin@cinci.rr.com"

<mbeljin@cinci.rr.com>
cc
Barbara Ritchie <BARBARA.RITCHIE@fmc.com>, Marc Bowman <Marc.E.Bowman@us.mwhglobal.com>, Douglas Oliver Jr. <Douglas.S.Oliver@us.mwhglobal.com>, Zachary Brown <Zachary.A.Brown@us.mwhglobal.com>, "'Prouty, Alan L'" <Alan.Prouty@simplot.com>, Andy Koulermos <akoulermos@newfields.com>
Subject
September 21, 2009 FMC Groundwater Model Meeting Presentation

The presentation from yesterday's FMC Groundwater Model meeting is attached. The meeting minutes will be circulated to this route list next week. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com
(See attached file: FMC SFS GW Model Meeting 21Sept09 Presentation.pdf)

Rob Hartman

From: Rob Hartman
Sent: Monday, October 05, 2009 4:31 PM
To: 'Lynch.Kira@epamail.epa.gov'; 'Zavala.Bernie@epamail.epa.gov'; 'Scott.Miller@deq.idaho.gov'; 'Doug Tanner'; 'Kelly Wright'; 'Susan Hansen'; 'Fisher.Carla@epa.gov'; 'Ross.Randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: 'Barbara Ritchie'; Marc Bowman; Douglas Oliver Jr.; Zachary Brown; 'Prouty, Alan L'; 'Andy Koulermos'
Subject: Minutes from September 21 2009 FMC GW Modeling Meeting and Schedule Follow-up
Attachments: GW Flow Model Meeting Minutes 21Sep09.pdf; FMC SFS GW Model Meeting 21Sept09 Presentation.pdf

On behalf of FMC, I am routing a copy of the meeting minutes from the September 21, 2009 FMC Groundwater Modeling Meeting. The meeting presentation is also attached to the meeting minutes (and to this email).

As we discussed during the September 21 meeting, the next FMC groundwater model meeting, to present the predictive simulations for the groundwater remedial alternatives, is scheduled for October 21, 2009 in Boise. MWH's Boise office is available for the October 21 meeting and has the IT infrastructure to support a webcast/teleconference for remote attendees. We suggest the meeting begin at 8:30 a.m. MDT and is expected to conclude by noon. We will circulate additional details (e.g., address and location map for MWH office and draft agenda) for the meeting by mid-next week.

Contact me if questions. Thank you, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
(208) 241-8216
Rob.J.Hartman@mwhglobal.com

Meeting Minutes
FMC Plant OU SFS Groundwater Modeling Meeting
Pocatello, Idaho
Conducted on September 21, 2009

Attendees:

U.S. EPA:	Kira Lynch, Bernie Zavala, Susan Skinner, Milovan Beljin(*), Randall Ross(*)
Idaho DEQ:	Scott Miller (*)
SBT:	Susan Hansen
FMC:	Barbara Ritchie
MWH:	Marc Bowman, Rob Hartman, Zak Brown, Doug Oliver

(*) via teleconference/webcast:

Key issues and discussion topics

The purpose of this meeting was to present the calibrated transport model and sensitivity analysis, discuss the details of the groundwater alternatives to be evaluated in the SFS, and provide preliminary results for the predictive simulations of the SFS alternatives.

Rob Hartman, Doug Oliver, and Zak Brown gave a presentation summarizing the flow model construction and calibration, the transport model calibration, and preliminary predictive results for the SFS groundwater alternatives. The associated PowerPoint presentation was converted to a pdf and is attached.

The following paragraphs summarize the main issues, comments, and questions that were raised during this meeting:

Flow Model Review

MWH provided an overview of the calibrated groundwater flow model. As discussed in the September 3rd conference call between the EPA, FMC, and MWH, areal recharge was increased to 12 inches/year for the irrigated agricultural areas north of I-86. With the change in recharge, the range in calibration errors was reduced slightly (-6.2 ft to +4.3 ft was reduced to -6.1 ft to +4.2 ft), but the other calibration statistics remained virtually unchanged. Based on data review and sensitivity analysis, the hydraulic conductivity (K) distribution for the northeastern area of the domain near the Portneuf River was not changed, as discussed in the September 3rd conference call.

Contaminant Transport Model Calibration

MWH presented results of the plume matching effort performed to calibrate the transport model. The purpose of the transport model calibration was to improve the estimates for transport parameters, in particular sorption/retardation and dispersivity values, to be used in the transport model for the predictive simulations. Plumes constructed with measured 1994 data were used as initial conditions and the model was run forward to predict 2008

conditions. Model predicted plumes for 2008 were compared to plumes generated with 2006-2008 data. While plumes with sources at FMC were matched reasonably well, plumes with sources at Simplot were not matched as well because contamination from the Simplot site was held at the 1994 level. As a result, the influence of the East Overflow Pond at Simplot was overpredicted, and the influence of the gypsum stack was underestimated. 2008 data will be used to generate the initial conditions for the predictive simulations.

Bernie Zavala asked why we multiplied the sorption (Kd) values by five rather than two in the sensitivity analysis. Doug Oliver replied the range evaluated was based on the relatively wide range of values reported in the literature.

MWH posted MODFLOW and MT3DMS files for the calibrated flow and transport models to the ftp site on September 16.

MWH ftp login information and instructions:

The ftp site link is: ftp.mwhglobal.com
Username: slc1-FMC

Groundwater Alternative Details and Preliminary Predictive Results

MWH/FMC presented the groundwater alternatives and preliminary results from predictive simulations generated with MODFLOW and MODPATH to predict capture zones and contaminant transport flow directions. Results were presented for Groundwater Alternative 1 (which includes source controls and long-term groundwater monitoring but no active groundwater extraction), Groundwater Alternative 2 (hydraulic containment near the Plant site boundary with three extraction wells), Groundwater Alternative 3 (pump and treat with wells in the former source areas identified as Areas A, B, and C from west to east), and a fourth alternative that included all wells from both Groundwater Alternative 2 and Groundwater Alternative 3.

Alternative 2+3, as configured prior to the meeting, captures a significant quantity of clean water north of the FMC site. There is also redundancy between the Alternative 3 Area C wells and the Alternative 2 Plant boundary wells. Furthermore, the combined pumping rates for the Area C wells and Plant boundary wells used in the model is likely unrealistic. EPA's objective for this alternative is a restoration remedy that provides hydraulic containment and reaches MCLs in groundwater beneath the Plant site within a reasonable timeframe. Bernie suggested that EPA generally considers a reasonable timeframe to be anything less than ~100 years. Kira Lynch suggested the Area C wells should be removed given the proximity of the Plant boundary wells (Alternative 2) that will capturing contaminated groundwater from this area and provide full containment. MWH will refine this alternative by removing the Area C wells. With this change, this alternative will be so similar to Alternative 3 that it may be most efficient to revise Alternative 3 by removing the Area C wells and adding the Alternative 2 containment wells and thereby eliminate a "fourth" alternative.

Bernie remains concerned about dewatering of extraction wells at the pumping rates used in the simulations for Alternatives 2 and 3. MWH will review pumping data for wells at Simplot and may reduce the pumping rates in individual wells and add more wells for each alternative. MWH/FMC will optimize the number of wells, well locations, and pumping rates. EPA would like to see pumping rates for individual wells for each predictive alternative. MWH will also evaluate the model-predicted drawdowns.

Scott Miller asked if any alternatives include recharge of treated water. Alternatives 2B and 3B will be identical to Alternatives 2 and 3, but will include surface infiltration basins to the west.

Milovan Beljin noted that the backward tracked particles sometimes appeared to cross. Zak Brown explained this is due to the particles changing layers. Milovan requested to see forward particle tracking throughout plumes in all layers for the alternatives.

Schedule

The following is a tentative schedule for the SFS groundwater modeling effort:

- 30 September 2009 - Teleconference with EPA to obtain feedback on transport model calibration.
- 21 October 2009 – Meet in Boise to present and discuss results of predictive simulations.
- Groundwater modeling report to be submitted as an appendix to the Draft SFS.

Action Items

During the FMC groundwater model review meeting on September 21, 2009, we captured the following list of action items:

1) Provide a copy of the meeting presentation slides to the "FMC groundwater model group" distribution list. **Follow-up:** Meeting presentation slides attached to these minutes.
2) EPA will discuss the transport calibration the week of September 28th and inform FMC/MWH if they consider the calibration sufficient. **Follow-up:** Based on follow-up discussions within EPA's project team and with Scott Miller, Bernie issued an email on September 29 stating that the tentative September 30 conference call would not be necessary. Bernie will follow-up directly with Rob Hartman regarding some additional questions.
3) EPA and FMC/MWH will coordinate to confirm the October 21 meeting in Boise to present results of the predictive simulations. In advance of the meeting, MWH/FMC will post the predictive model files on the MWH ftp site.

Rob Hartman

From: Rob Hartman
Sent: Tuesday, October 13, 2009 4:25 PM
To: Kira Lynch; Zavala.Bernie@epamail.epa.gov; Scott.Miller@deq.idaho.gov; Doug Tanner; Kelly Wright; Susan Hansen; Fisher.Carla@epa.gov; Ross.randall@epa.gov; mbeljin@cinci.rr.com
Cc: Barbara Ritchie; Marc Bowman; Doug Oliver; Zachary Brown; 'Prouty, Alan L'; Andy Koulermos (akoulermos@FormationEnv.com)
Subject: Draft Agenda for October 21, 2009 FMC Groundwater Model Meeting in Boise
Attachments: Draft Agenda for Oct 21 2009 FMC GW Model Meeting.docx; MWH Boise ID Location Map.pdf

A draft agenda for the October 21, 2009 FMC groundwater model meeting is provided in the attachment to this message. Note that the meeting is scheduled to begin at 10:00 a.m. MDT and will be held at the MWH office in Boise, ID. A map with the MWH office ("BOI-1") address, telephone number and directions to the office from the Boise airport / Interstate 84 is also attached.

The meeting will also be conducted as a webcast/teleconference using Microsoft Office Live Meeting (same platform used for the September 21 meeting/webcast). The webcast invitation and teleconference line information will be routed separately. Please contact me if you plan to attend via webcast/teleconference so we can plan accordingly. Thank you, Rob.

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Draft Agenda for Agency-FMC Meeting on FMC Groundwater Modeling
October 21, 2009, Boise, ID
MWH Office
10:00 – 2:00 p.m. MDT

10:00 Introductions

10:15 Groundwater flow and contaminant transport model review

- Review inputs and assumptions

10:45 Predictive results for refined groundwater remedial alternatives

- Extraction well locations and pumping rates
- Predictive particle tracking simulations
- Predictive contaminant transport simulations

12:00 Lunch Break

1:00 Meeting recap and next steps

FMC
Supplemental Feasibility Study Groundwater Modeling Update

October 21, 2009
Boise, Idaho

MWH

BUILDING A BETTER WORLD

Modeling Objectives

- Development of a tool that can support the Supplemental Feasibility Study and compare remedial alternatives for the FMC Plant Operable Unit of the Eastern Michaud Flats Superfund Site
- Groundwater flow model was developed to provide the underlying flow regime for contaminant fate and transport simulations
- Contaminant transport calibration was performed to improve estimates of transport parameters for predictive simulations
- Predictive transport simulations were run to compare SFS remedial alternatives and estimate time to achieve the groundwater restoration RAO

Contaminants Simulated

- Arsenic
  - Primary risk driving groundwater COC
- Total Phosphorus/Orthophosphate
  - Primary (groundwater to) surface water COC
- Potassium
  - Key indicator of FMC source areas

Transport Model Calibration

Plume Matching Process

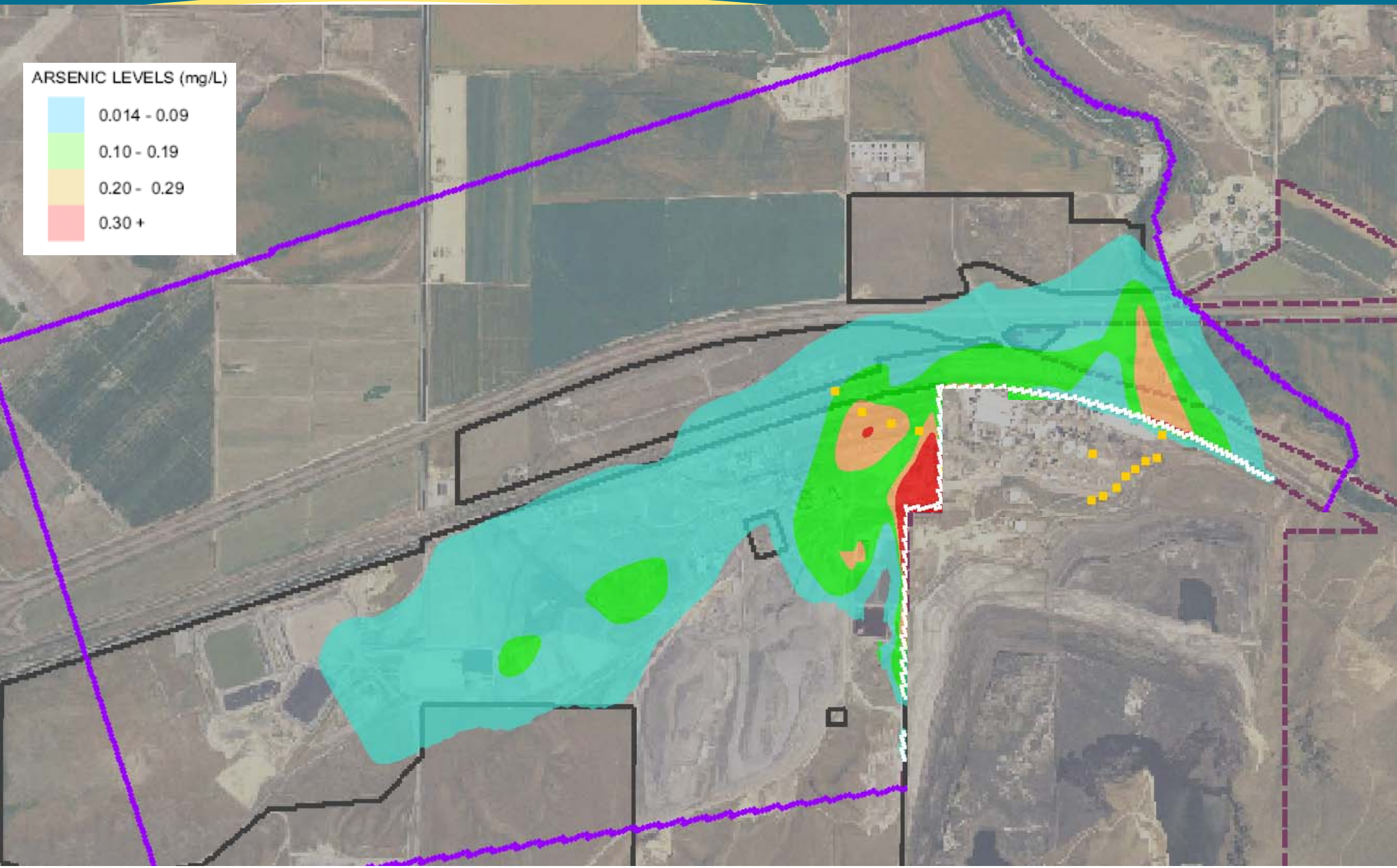
- 1994 plumes used as initial conditions
- Ongoing sources assumed at Pond 8S, Old Phossy Ponds 3E-6E (beneath Pond 15S area), and Simplot
- Plume matching process involved adjusting sorption/retardation, dispersivity, porosity, and source strength
- Simulated 2008 contaminant plumes were compared to plume maps generated with measured concentrations (average 2006-2008 data)

Causes of Differences Between Observed and Simulated Plumes

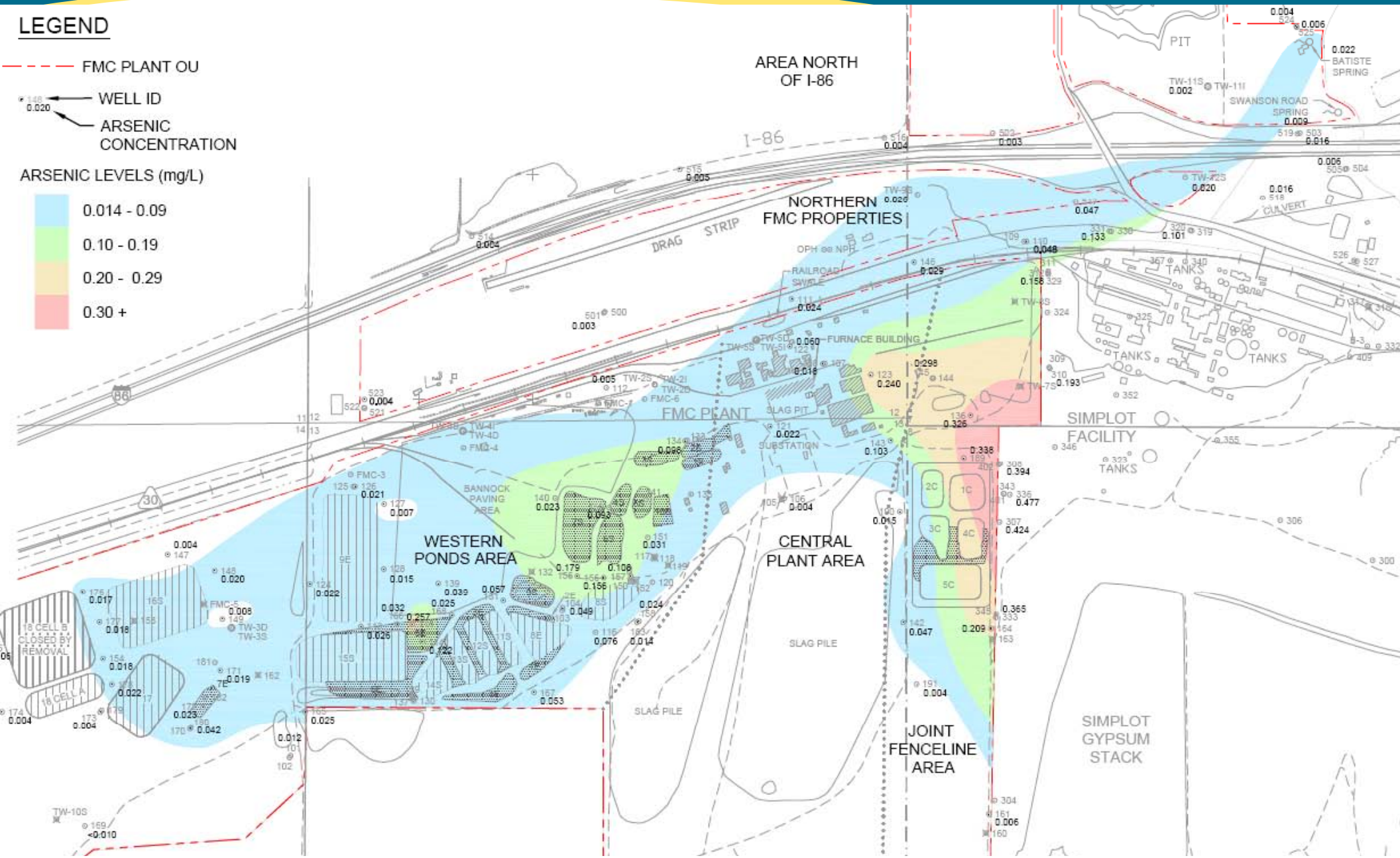
- Simplot gypsum stack input concentrations assumed constant at 1994 levels
- Simplot east overflow pond input concentrations assumed constant at 1994 levels
- No 1994 contaminant data were available from west end of FMC site (Pond 17 & 18 wells installed post-RI)
- These assumptions, simplifications, and data gaps lead to differences between 2008 observed and simulated plumes

Model-Predicted Arsenic Plume (2008)

Preliminary – Subject to Change

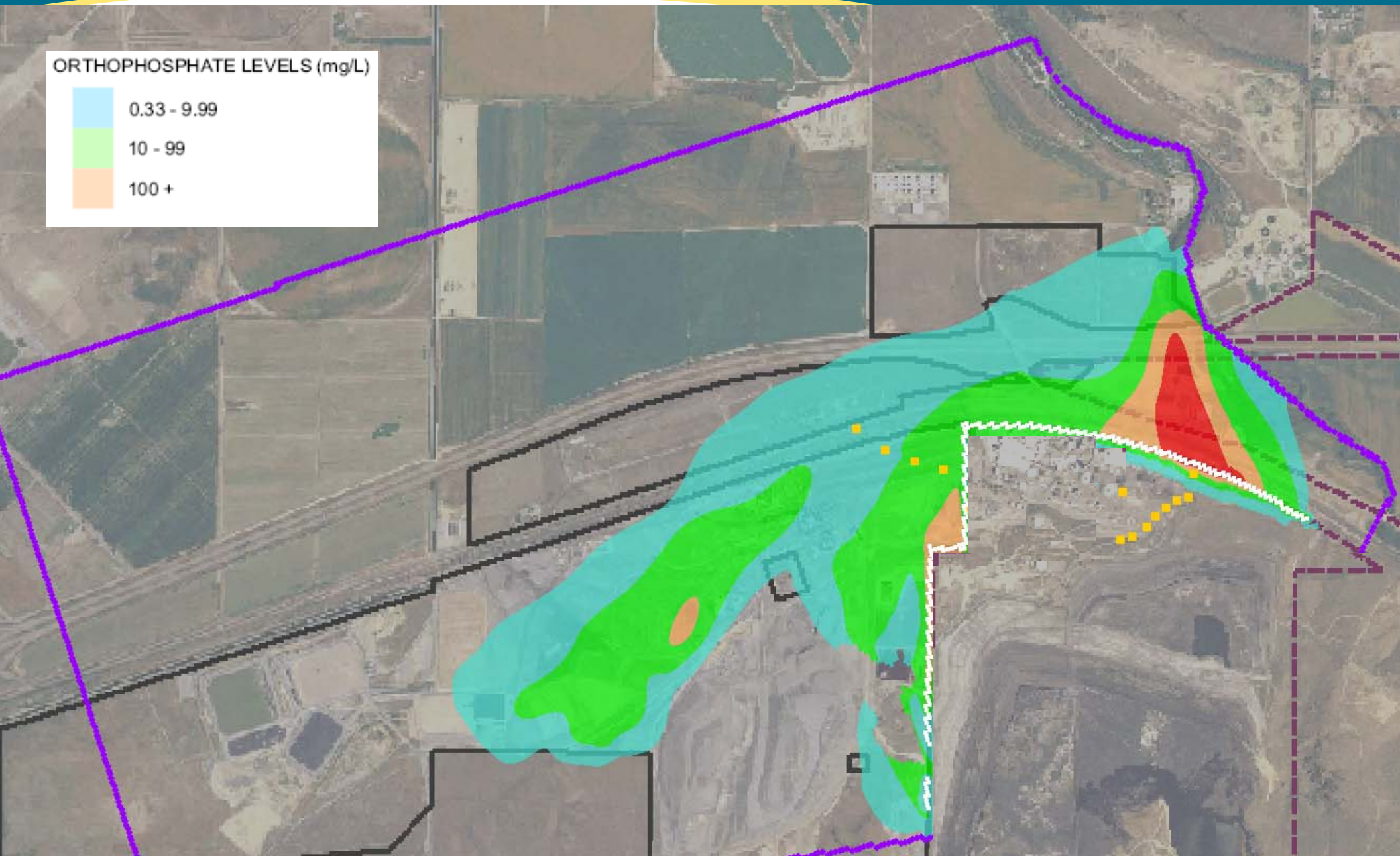


Observed Arsenic Plume (2008)

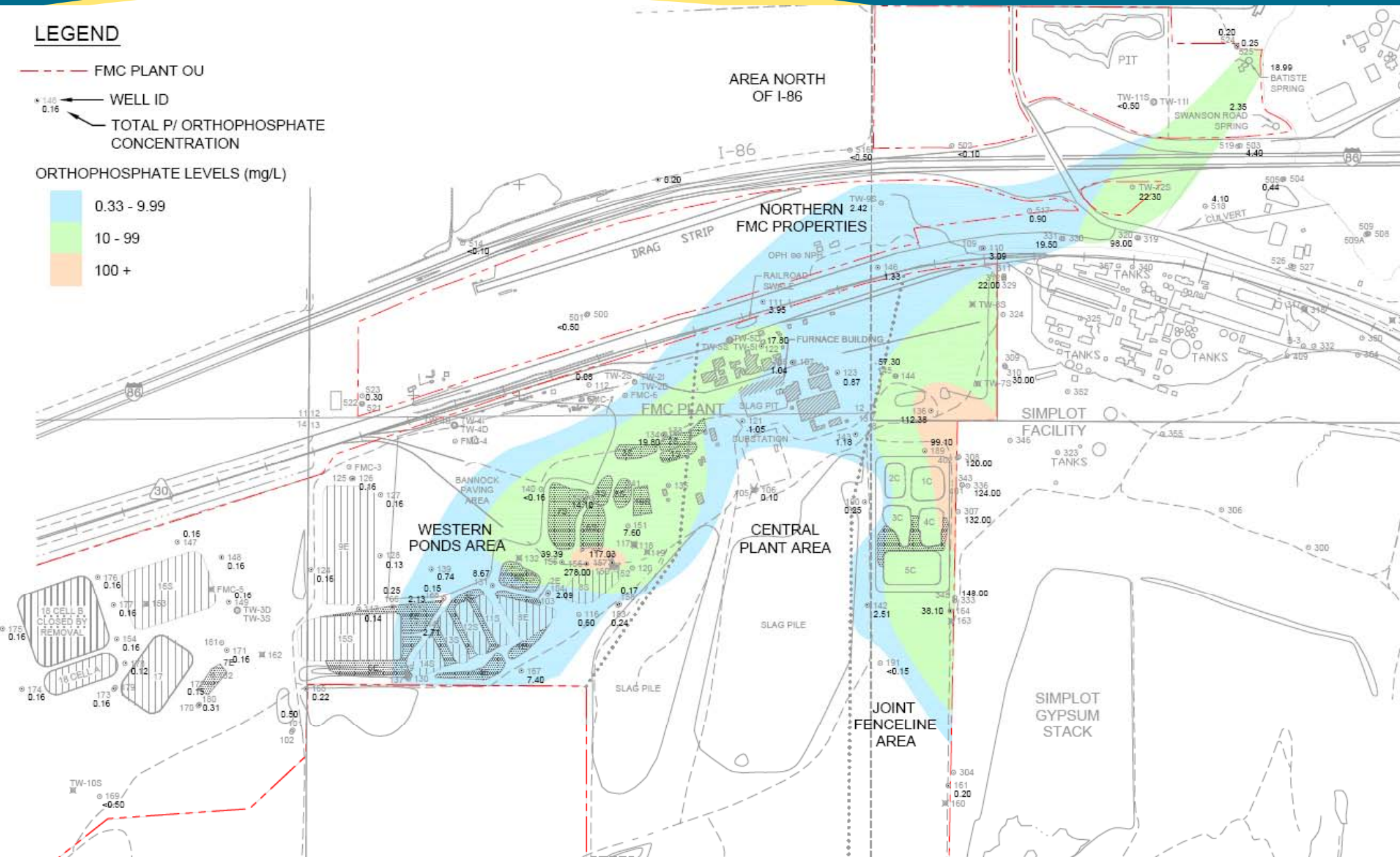


Model-Predicted Orthophosphate Plume (2008)

Preliminary – Subject to Change

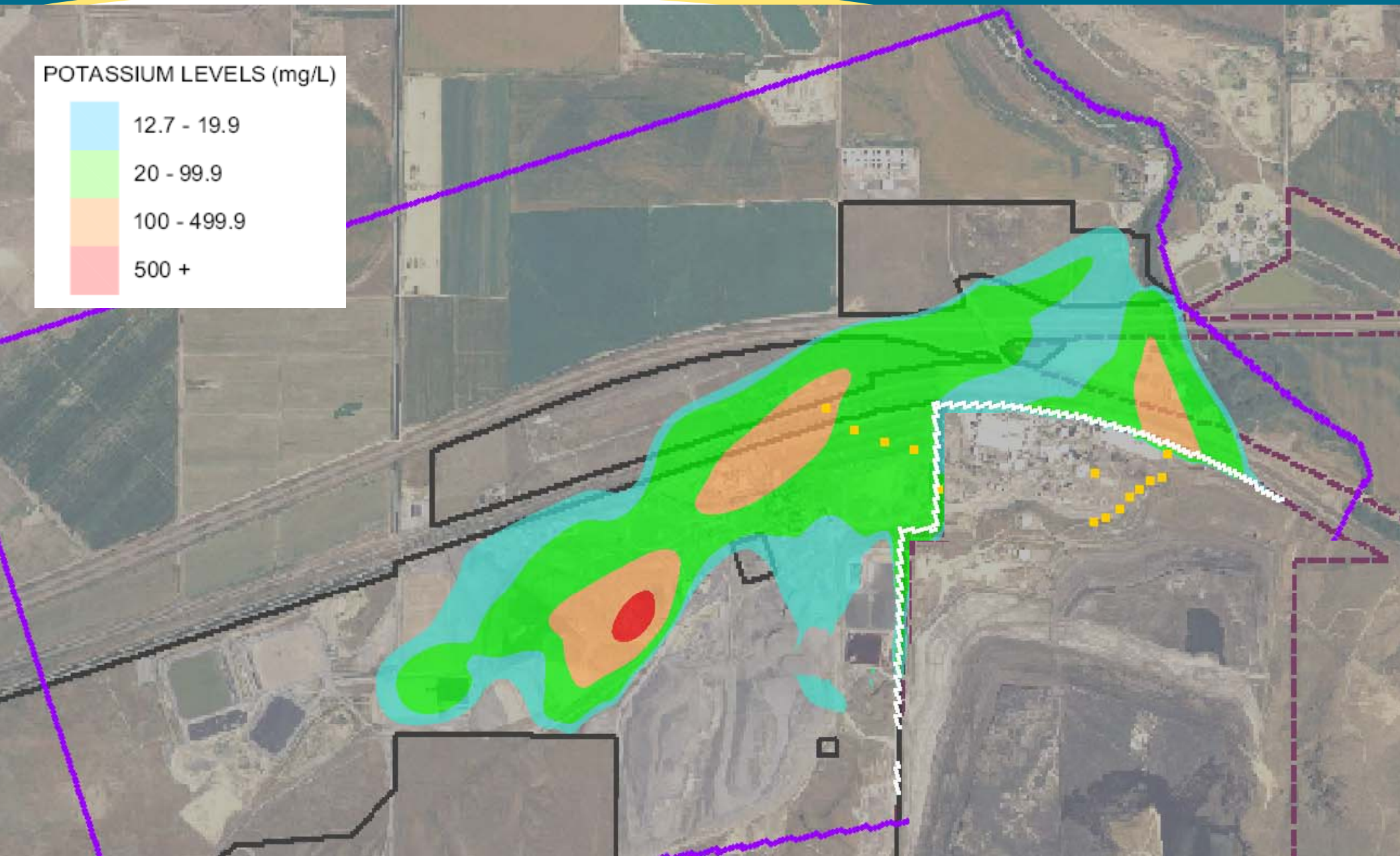


Observed Orthophosphate Plume (2008)

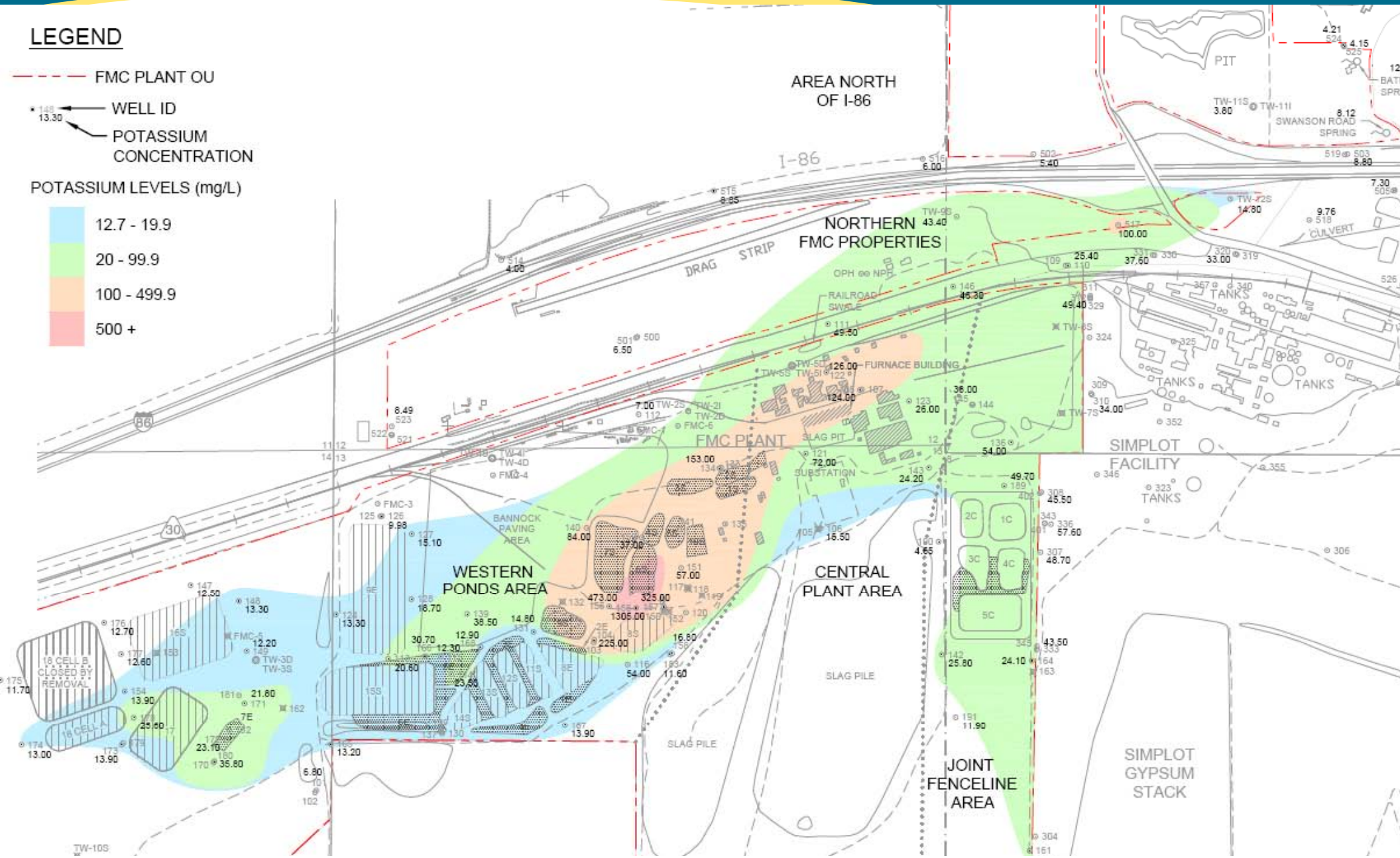


Model-Predicted Potassium Plume (2008)

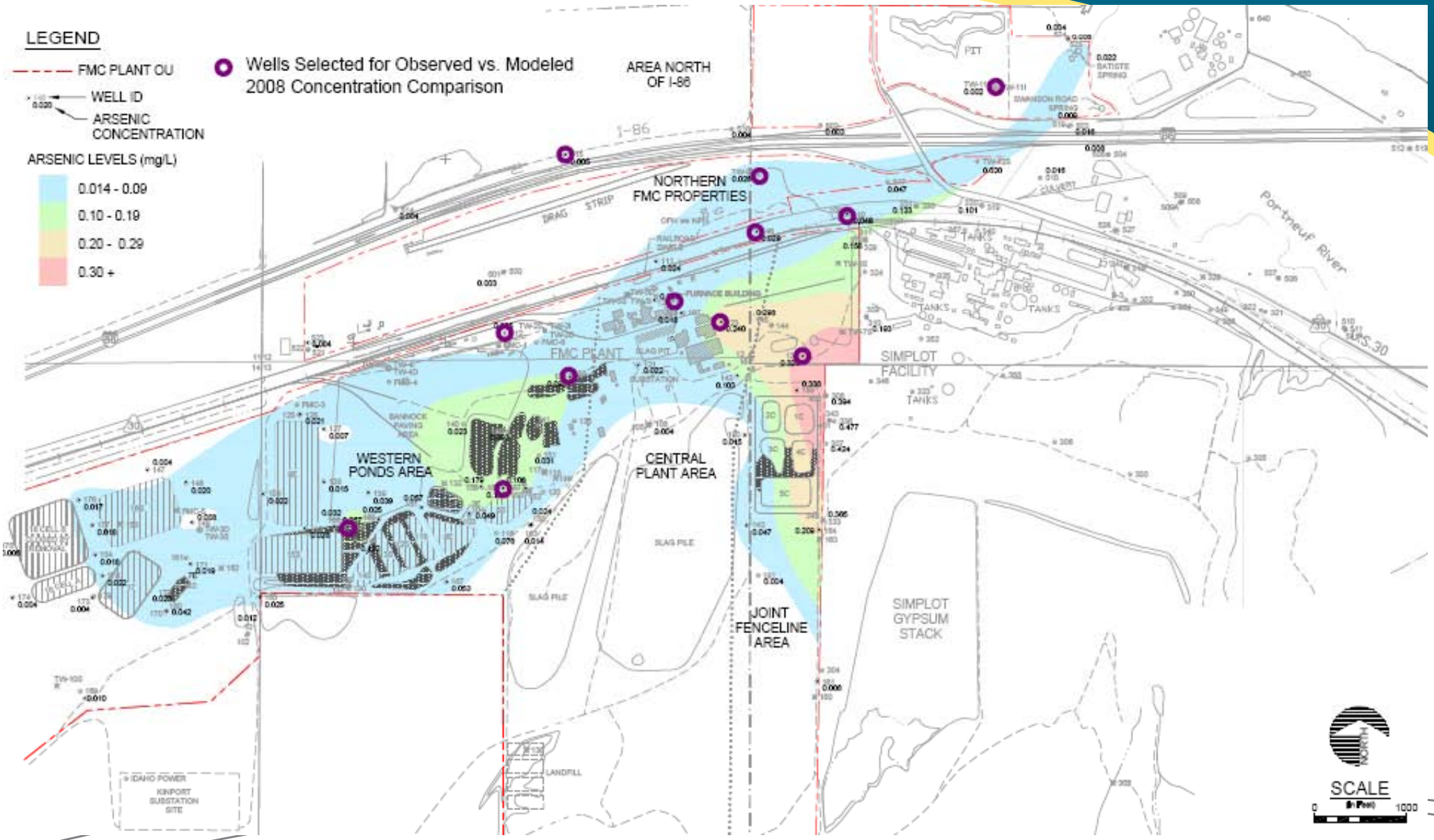
Preliminary – Subject to Change



Observed Potassium Plume (2008)



Wells Selected for Observed vs. Modeled 2008 Concentration Comparison



2008 Concentrations (mg/l) at Selected Observation Wells

Station ID	Observed Arsenic	Simulated Arsenic	Observed Orthophosphate / Total P	Simulated Orthophosphate / Total P	Observed Potassium	Simulated Potassium
WELL-115	0.26	0.14	2	4	12	13
WELL-156	0.16	0.12	278	330	1305	1045
WELL-134	0.10	0.07	20	46	153	145
WELL-122	0.06	0.06	18	13	126	130
WELL-123	0.24	0.12	1	5	26	37
WELL-136	0.33	0.20	112	45	54	31
WELL-110	0.05	0.09	3	19	25	39
WELL-146	0.03	0.14	1	3	46	98
TW-9S	0.03	0.02	3	5	58	72
WELL-112	0.01	0.02	1	1	7	14
WELL-515	0.01	0.00	0	0	9	2
TW-11S	0.00	0.01	1	1	5	20

Concentrations in mg/L

Plume Matching Summary

- 2008 plume lengths and widths matched for arsenic, orthophosphate, and potassium
- 2008 distribution of contamination matched reasonably well on the FMC plant site
- Transport calibration was performed to improve estimates of transport parameters for predictive simulations
- Measured 2008 contaminant data was imported for predictive simulation initial conditions

Calibrated Transport Parameters

Effective Porosity

- 35 percent

Longitudinal Dispersivity

- Initial Estimate of 55 feet based on plume length method: $\alpha_L = 0.82(\mathrm{Log}_{10}L)^{2.446}$ (Xu & Eckstein, 1995)
- Final calibrated value of 25 feet (transverse = 2.5 feet, vertical = 0.25 feet)

Sources

- Pond 8S (recharge rate = 2×10^{-5} inch/year)
  - 0.62 mg/l Arsenic, 3000 mg/l Potassium, 3700 mg/l Phosphate
- Pond 3E-6E (recharge rate = 2×10^{-5} inch/year)
  - 0.62 mg/l Arsenic

Final Transport Parameters

Sorption and Retardation

- Arsenic
  - K_d = 2.8 ml/g (literature range 1-29 ml/g)
  - R = 13
- Orthophosphate
  - K_d = 2.3 ml/g
  - R = 11
- Potassium
  - K_d = 2.8 ml/g (literature value 15 ml/g)
  - R = 13

Sensitivity Analysis Results

Transport parameters (sorption, dispersivity, porosity) were varied within reasonable ranges and the results were compared to the calibrated plumes:

- K_d x 5 = too little plume migration, very little change from initial conditions
- K_d / 5 = too much plume migration and dilution of higher concentration areas
- D x 10 = more disperse plumes, poor simulation of higher concentration areas
- D / 10 = only slightly less disperse plumes
- n + 10% = no significant change from the calibrated plumes
- n – 10% = no significant change from the calibrated plumes

Overall, the transport model was highly sensitive to changes in the sorption coefficients, and much less sensitive to the other transport parameters

Predictive Simulations of GW Alternatives

GW Alternative 1

- Source Controls (i.e., Soil Remedial Actions)
- Institutional Controls (Prevent use/ingestion of site-impacted groundwater)
- Long-term groundwater monitoring

GW Alternative 2

- Alternative 1 components
- Groundwater extraction for hydraulic containment at plant boundary
- Treatment and/or use of extracted groundwater

GW Alternative 3

- Alternative 1 components
- Groundwater extraction at identified source areas
- Treatment and/or use of extracted groundwater

Predictive Simulation Assumptions

- Initial conditions for contaminant distribution based on observed 2008 data

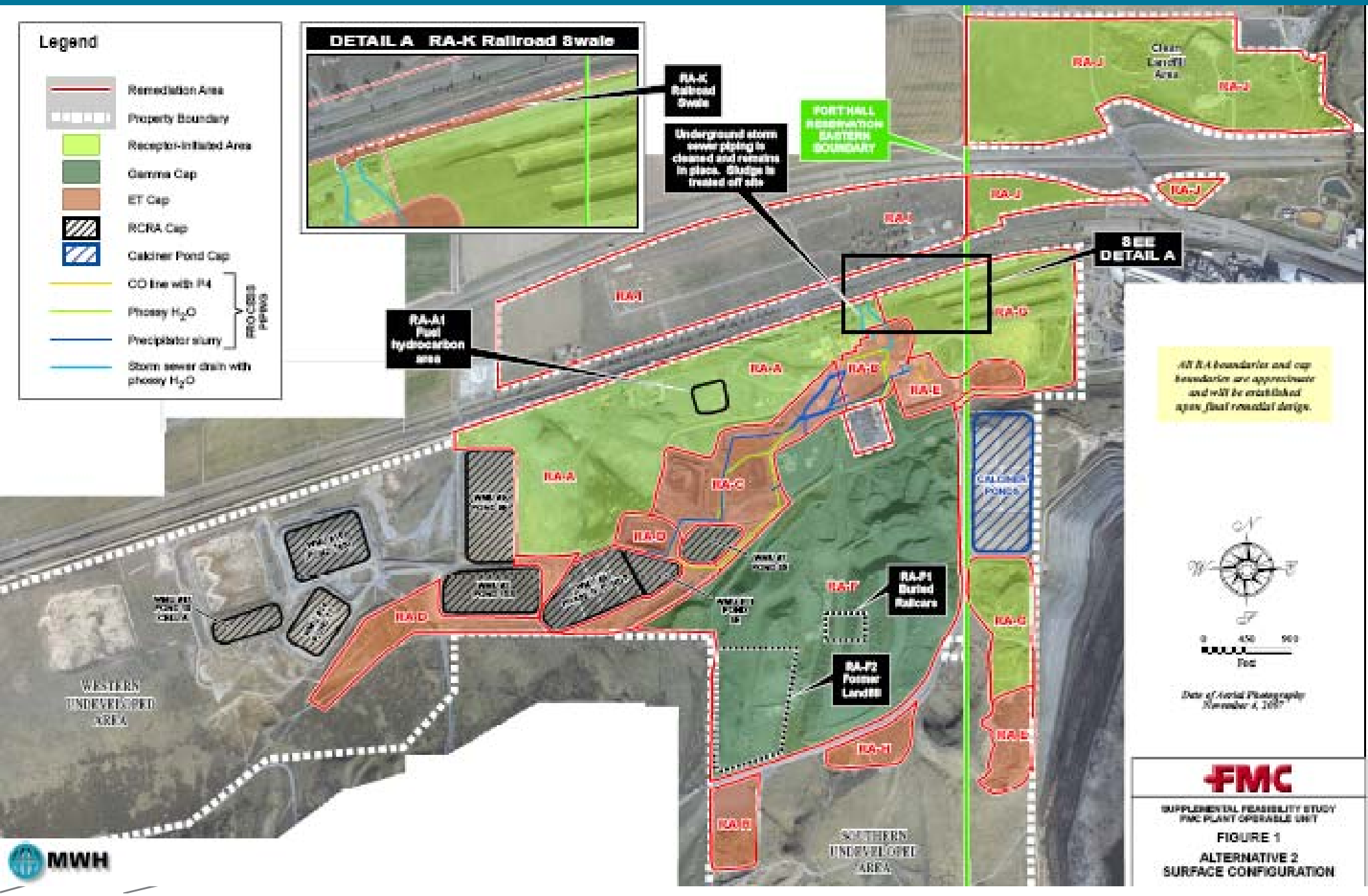
- Simplot
  - recharge from gyp stack = ~900 gpm (2009-2015)
  - recharge from gyp stack = 0 (after 2015)
  - pumping assumed constant based on 2008 rates
  - specified concentration at fence line based on 2008 data

- 2 steady-state flow models (2009-2015, 2015+)

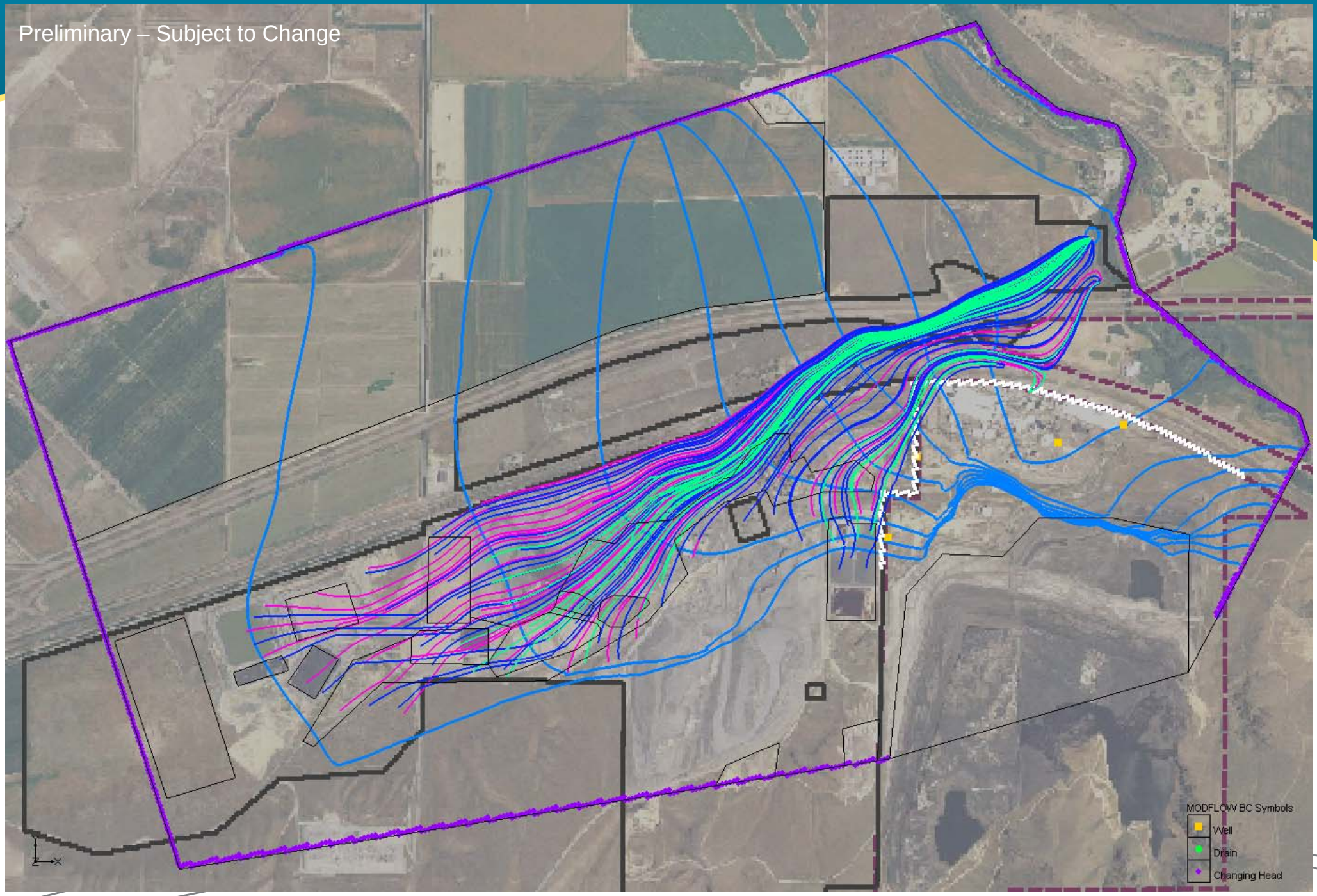
Predictive Simulation Assumptions (continued)

- Existing caps incorporated in calibrated flow model
  - RCRA and Calciner Pond Caps assigned infiltration rate = 2×10^{-5} inch/year
- SFS Assembled Soil Alternatives
  - Soil Alternative 2 ET Cap RAs assigned infiltration rate = 0.05 inch/year
  - Gamma Cover = natural infiltration rate = 1.2 inch/year
  - No changes in recharge would result from soil alternatives that include excavation and removal

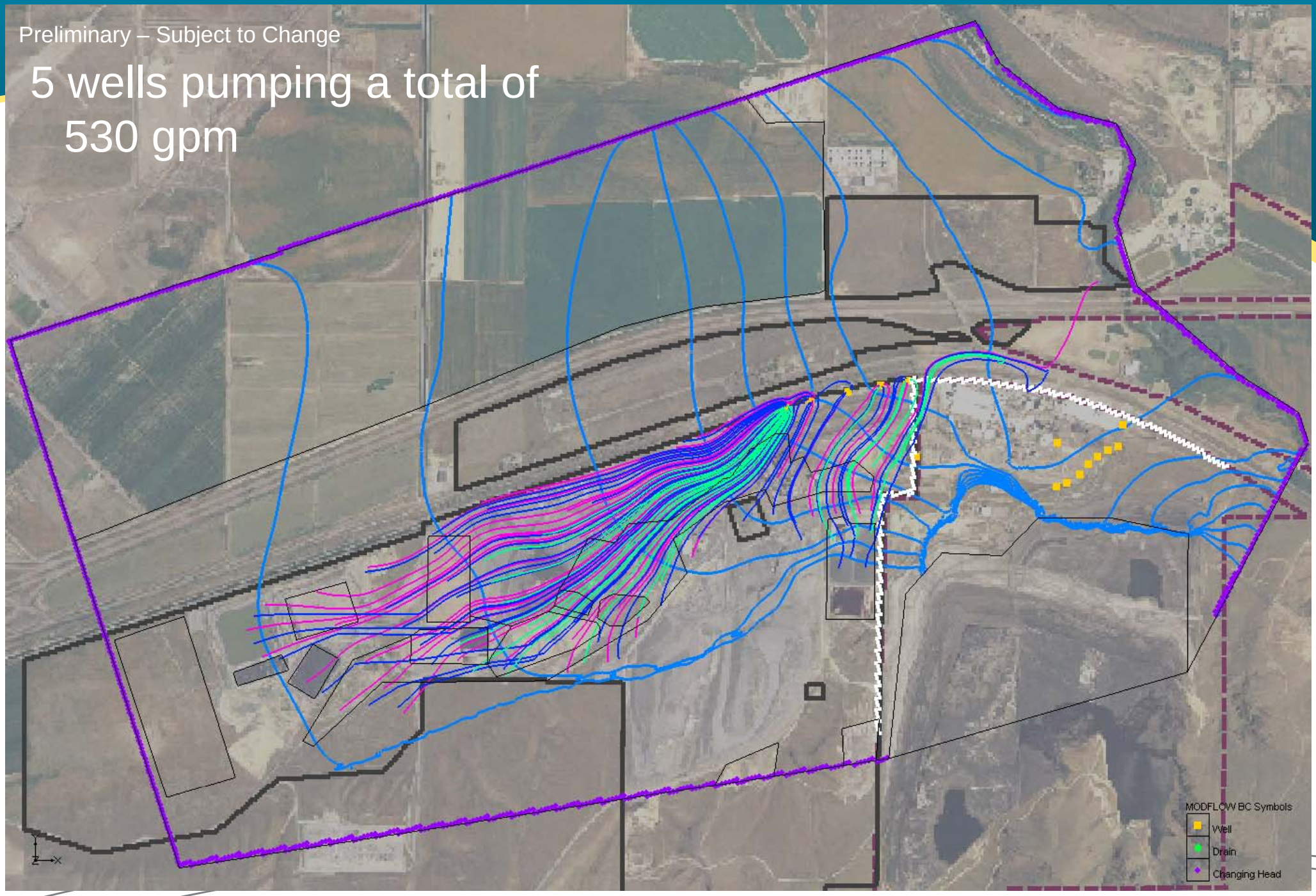
Soil Alternative 2



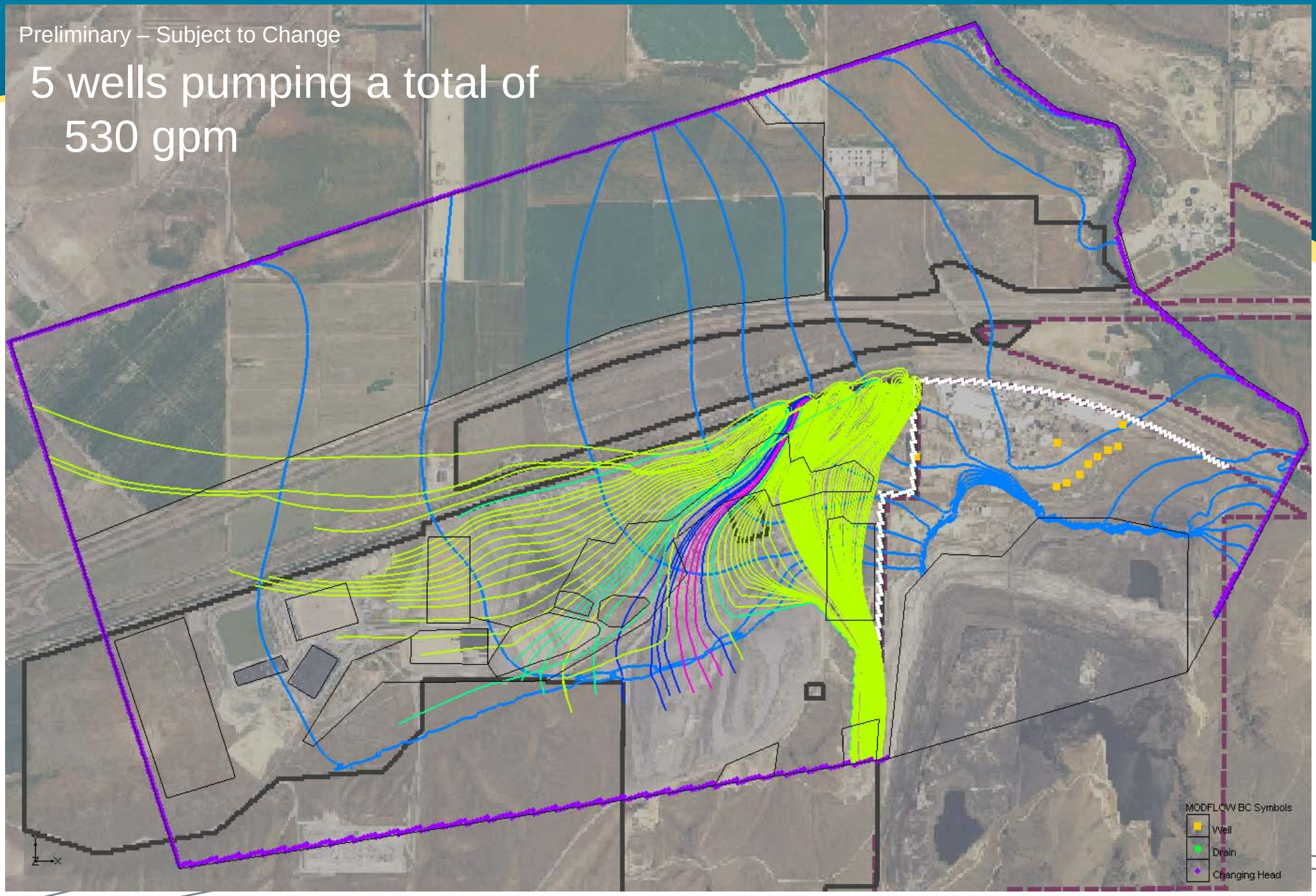
GW Alternative 1: Forward Particle Tracking



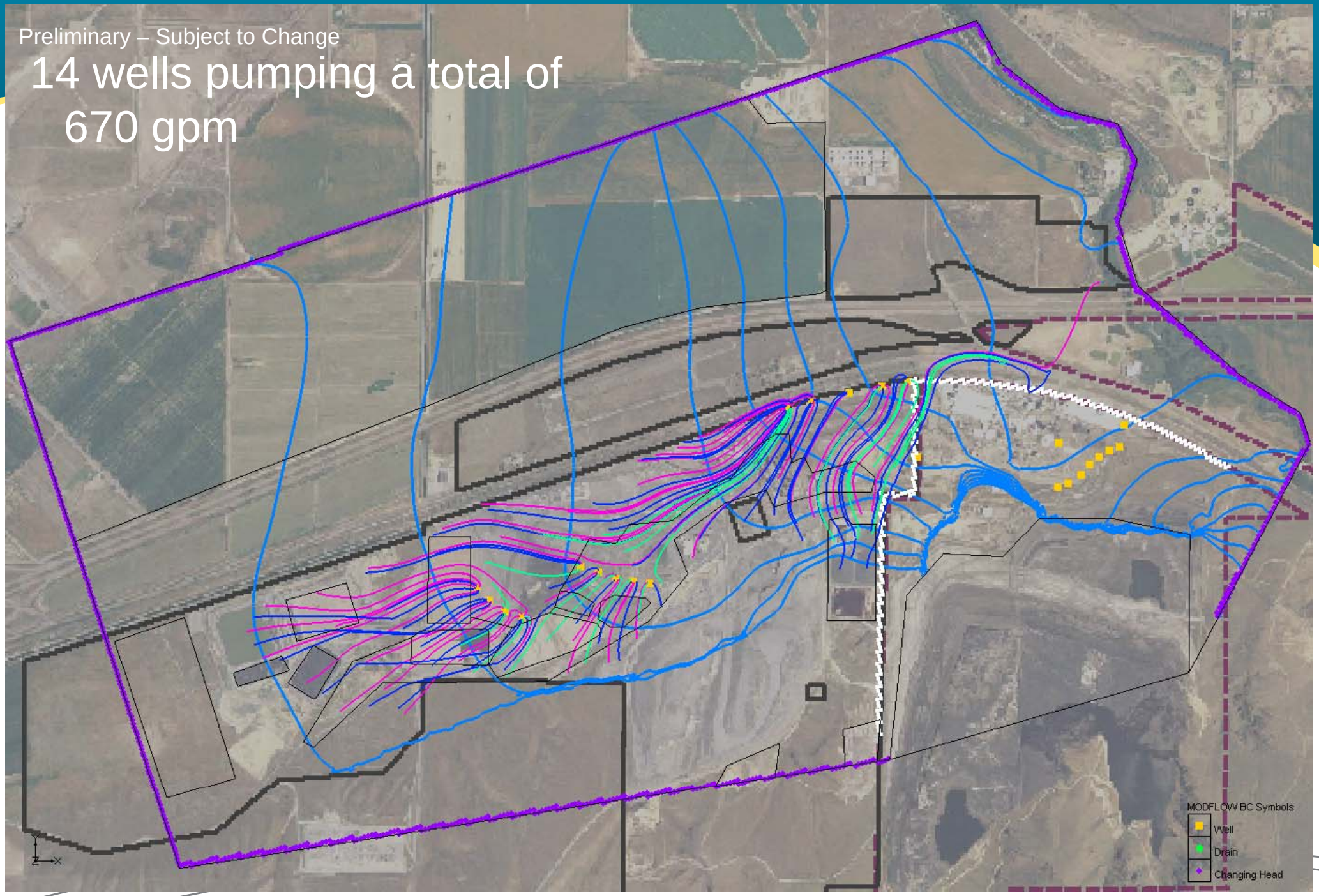
GW Alternative 2: Forward Particle Tracking



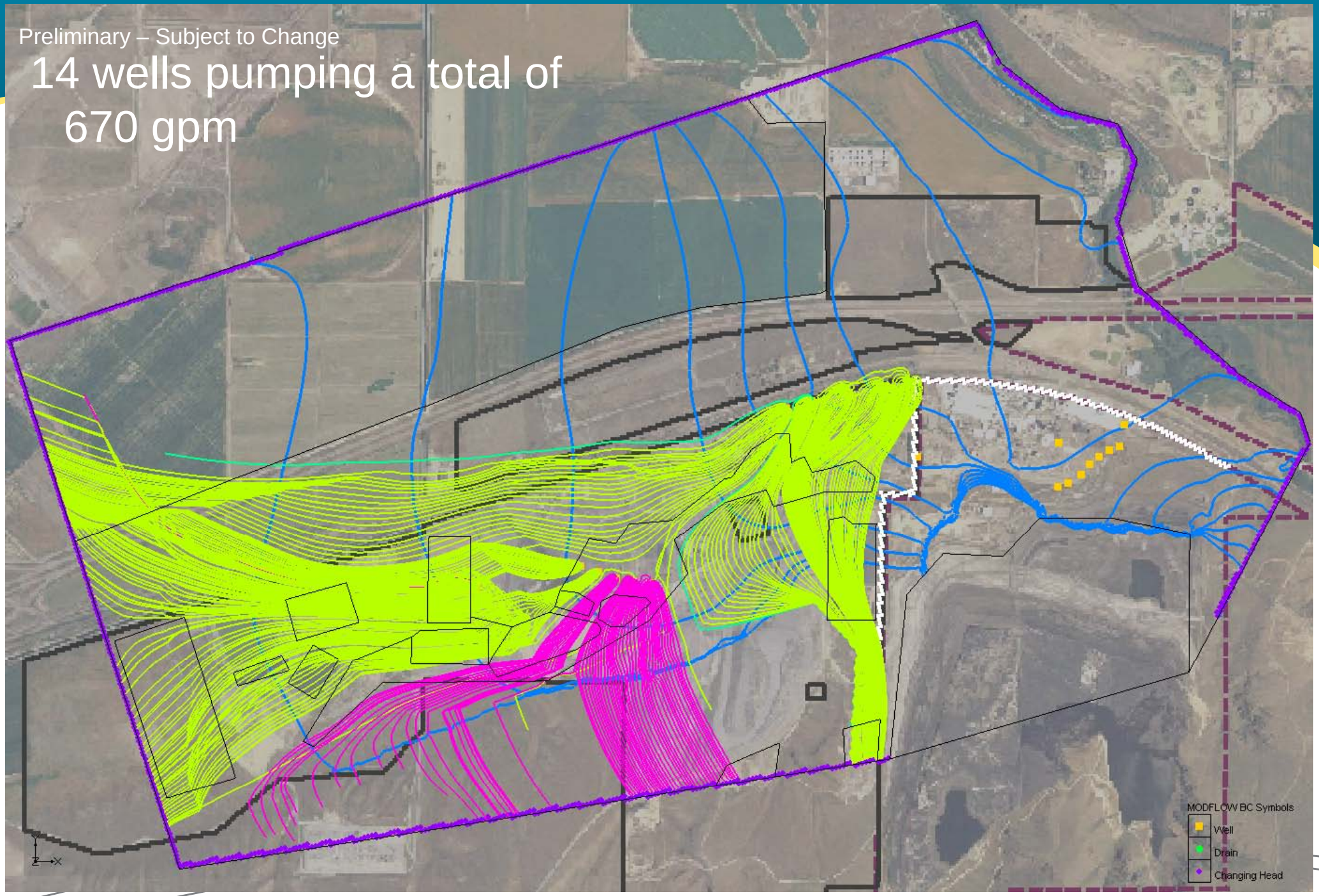
GW Alternative 2: Capture Zones



GW Alternative 3: Forward Particle Tracking



GW Alternative 3: Capture Zones



Simulated Flow Rates and Observed 2008 Concentrations

Alternative	Zone	Modeled Extraction Rate (gpm)	Observed Avg Arsenic (mg/l)	Observed Avg Total P (mg/l)
1		0	NA	NA
2A	Plant Site Boundary	530	0.035	2.5
3A	Plant Site Boundary	520	0.035	2.5
	Pond 3E-6E Area	60	0.14	1.9
	Pond 8S Area	90	0.15	145
	Total	670		

Alternative Simulations

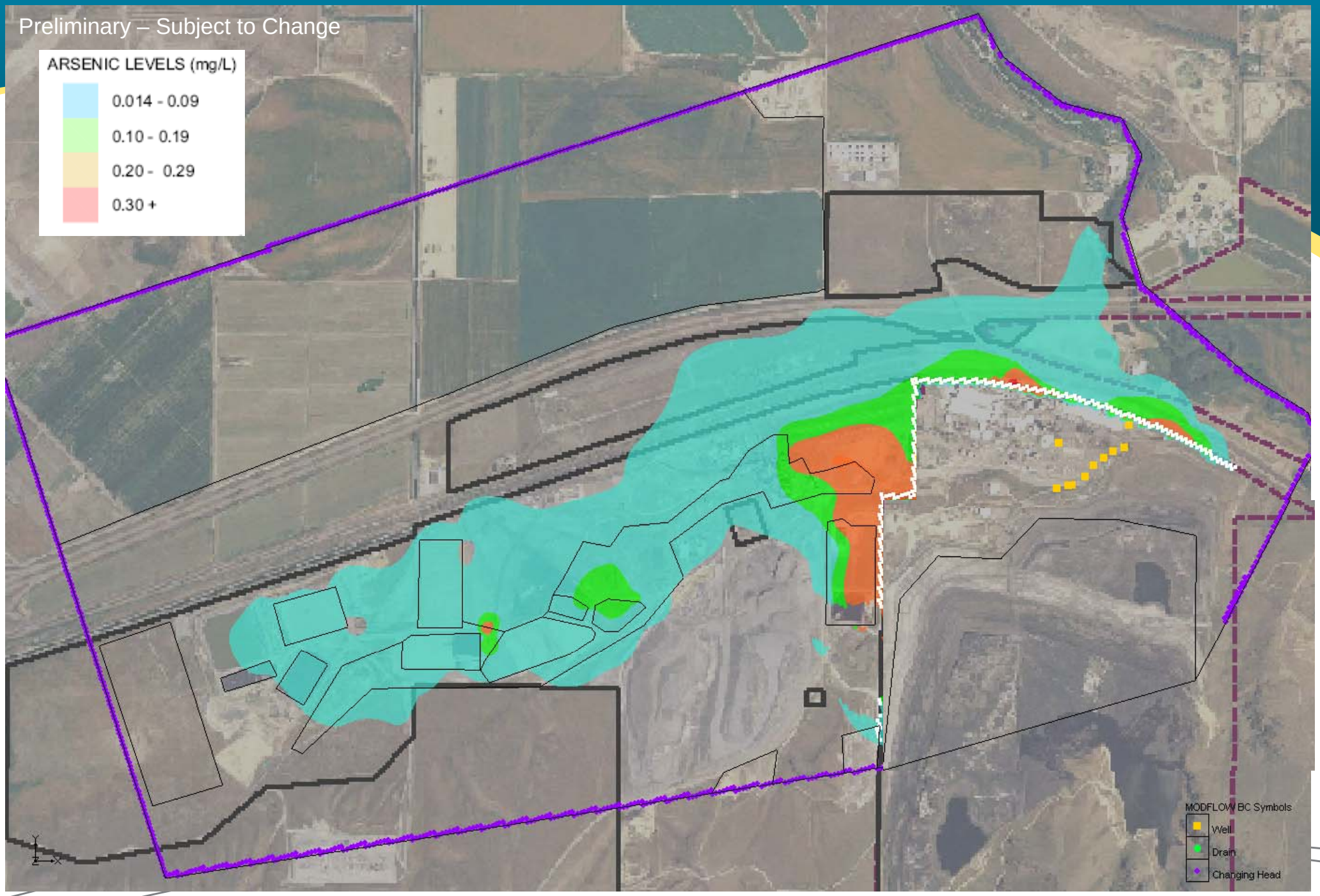
- Alternatives Simulated:
  - Alternative 1 – no extraction
  - Alternative 2A – extraction for hydraulic containment and treatment/discharge to POTW
  - Alternative 2B – extraction for hydraulic containment and treatment/discharge to on-site evaporation / percolation ponds in western area of site
  - Alternative 3A – extraction for aquifer restoration and treatment/discharge to POTW
  - Alternative 3B – extraction for aquifer restoration and treatment/discharge to on-site evaporation / percolation ponds in western area of site

Remedial Alternative Simulations

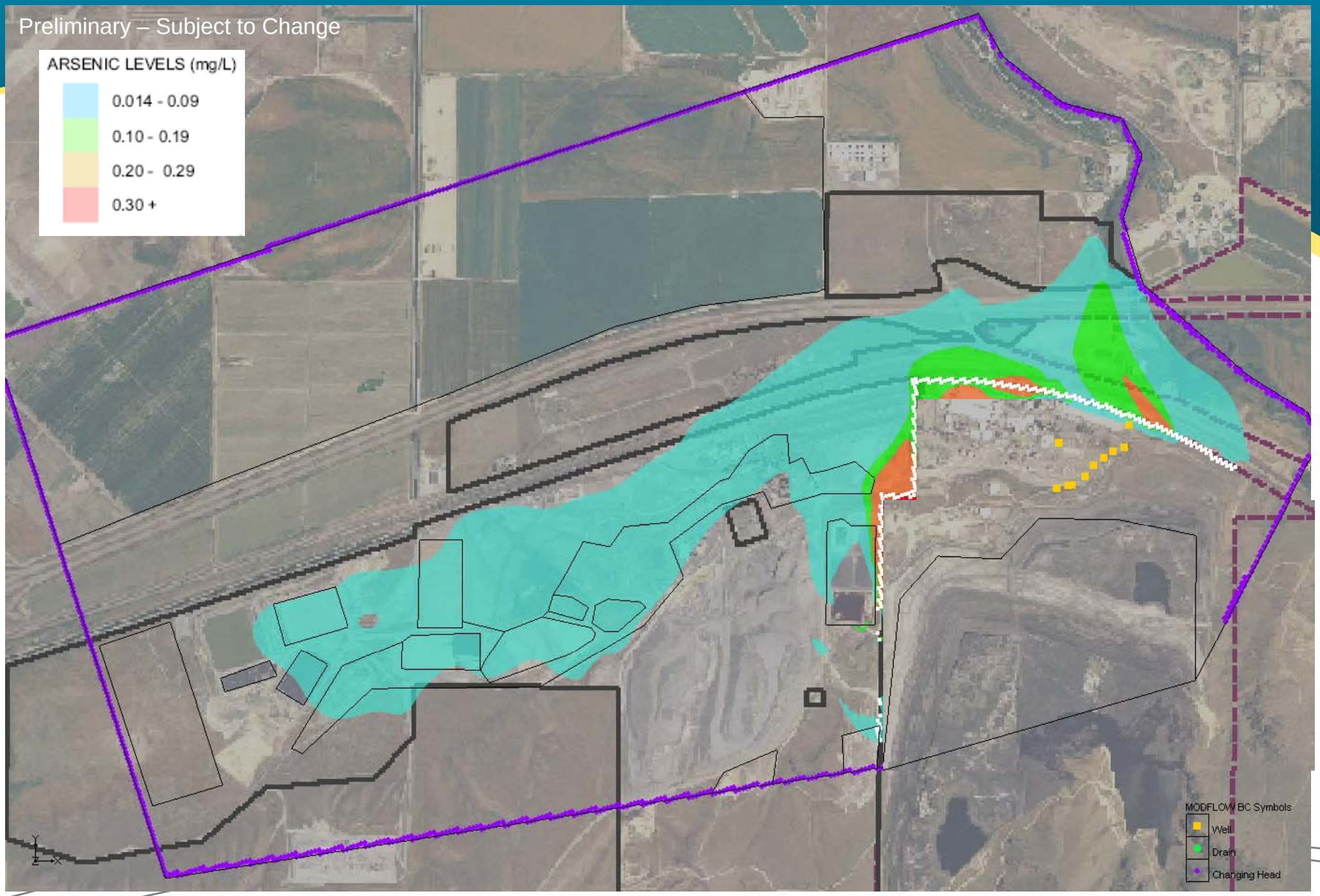
- Simulated 100-year performance consistent with EPA guidance on reasonable time-frame

- Output for review today:
  - Initial, 25, 50 and 100 year predicted arsenic plumes for alternatives 1, 2A and 3A (alternatives 2B and 3B output not materially different)
  - Initial condition to 100 year animations for predicted arsenic plumes for alternatives 1, 2A and 3A

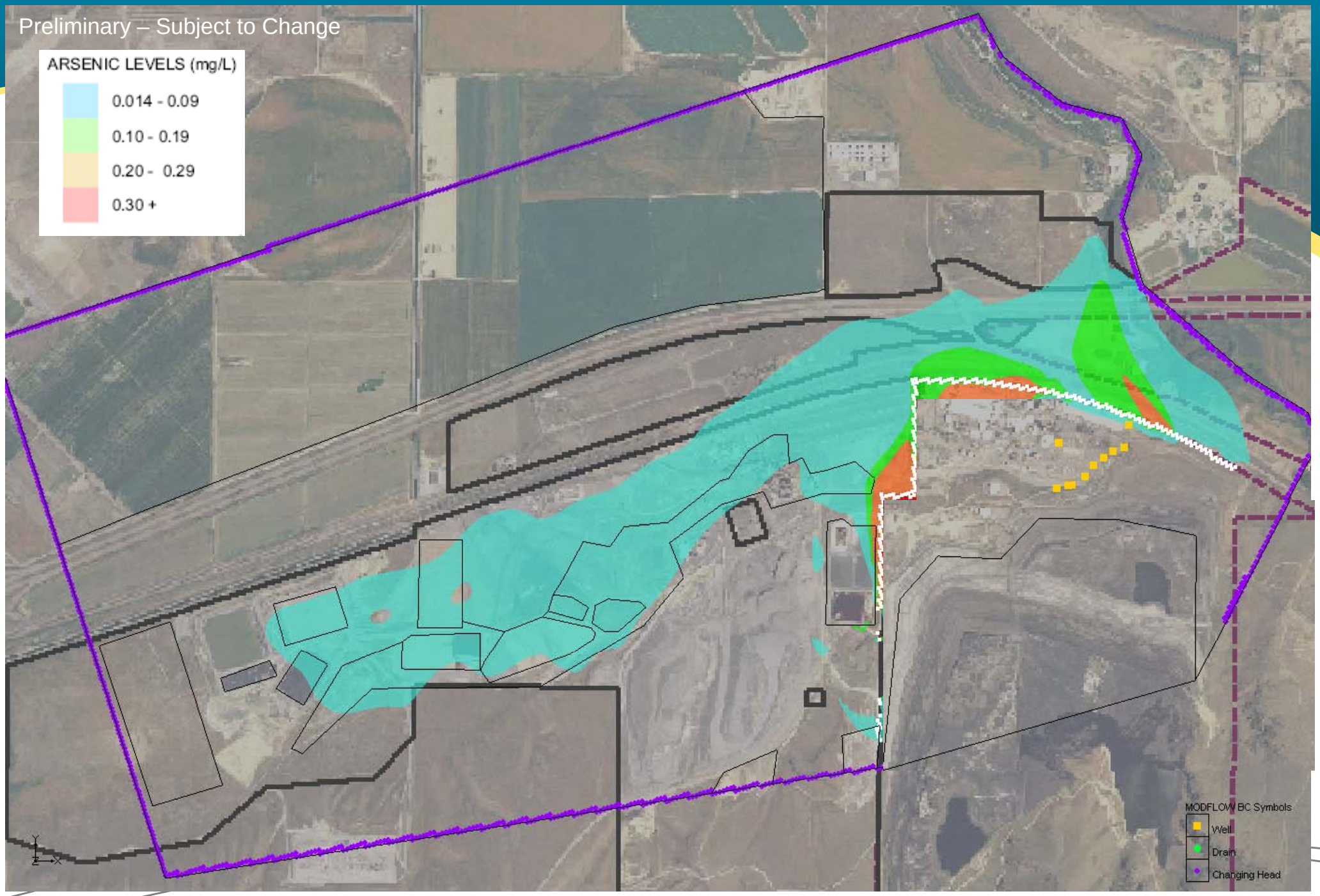
Alternative 1 – Arsenic Initial Condition



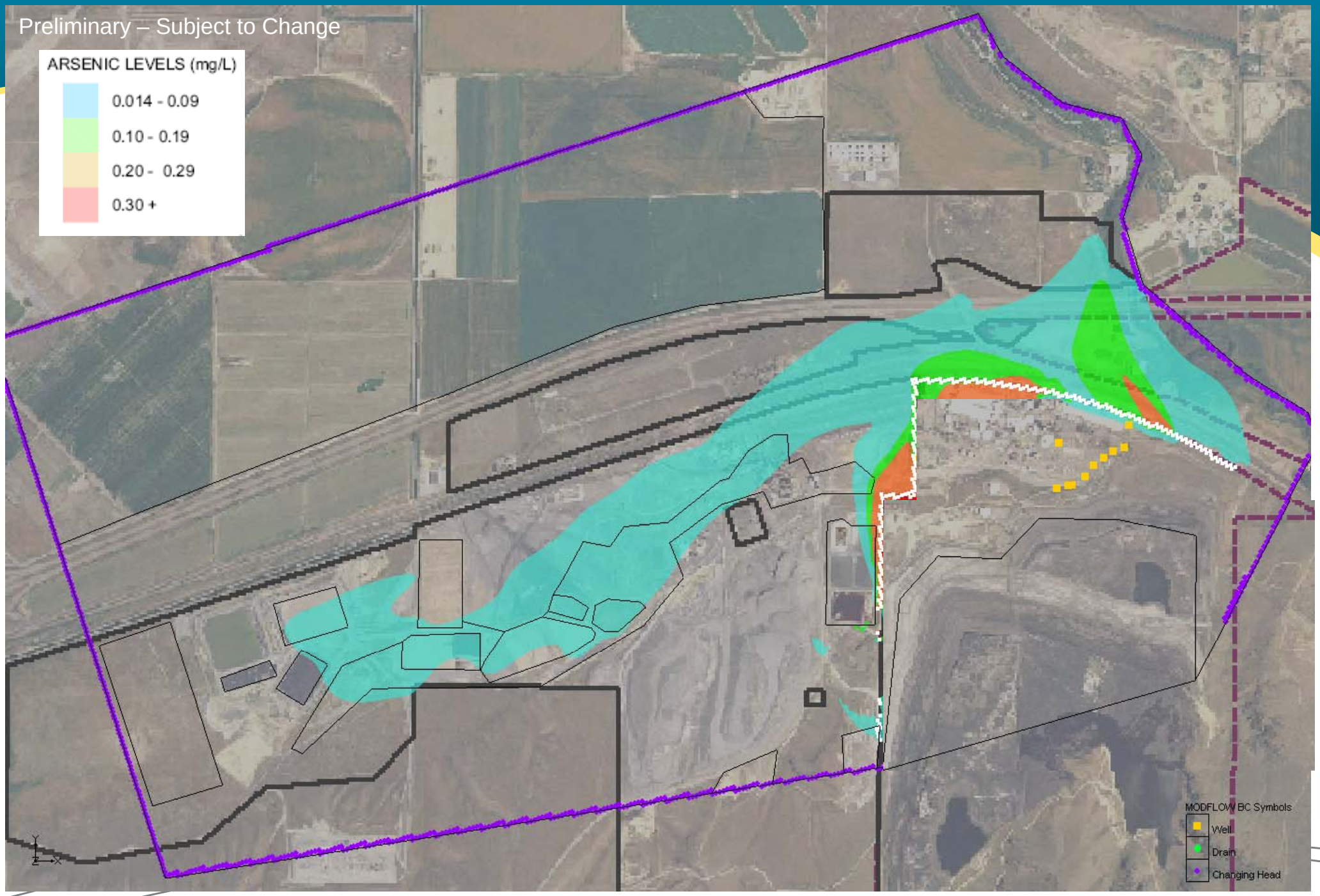
Alternative 1 – Arsenic at 25 Years



Alternative 1 – Arsenic at 50 Years

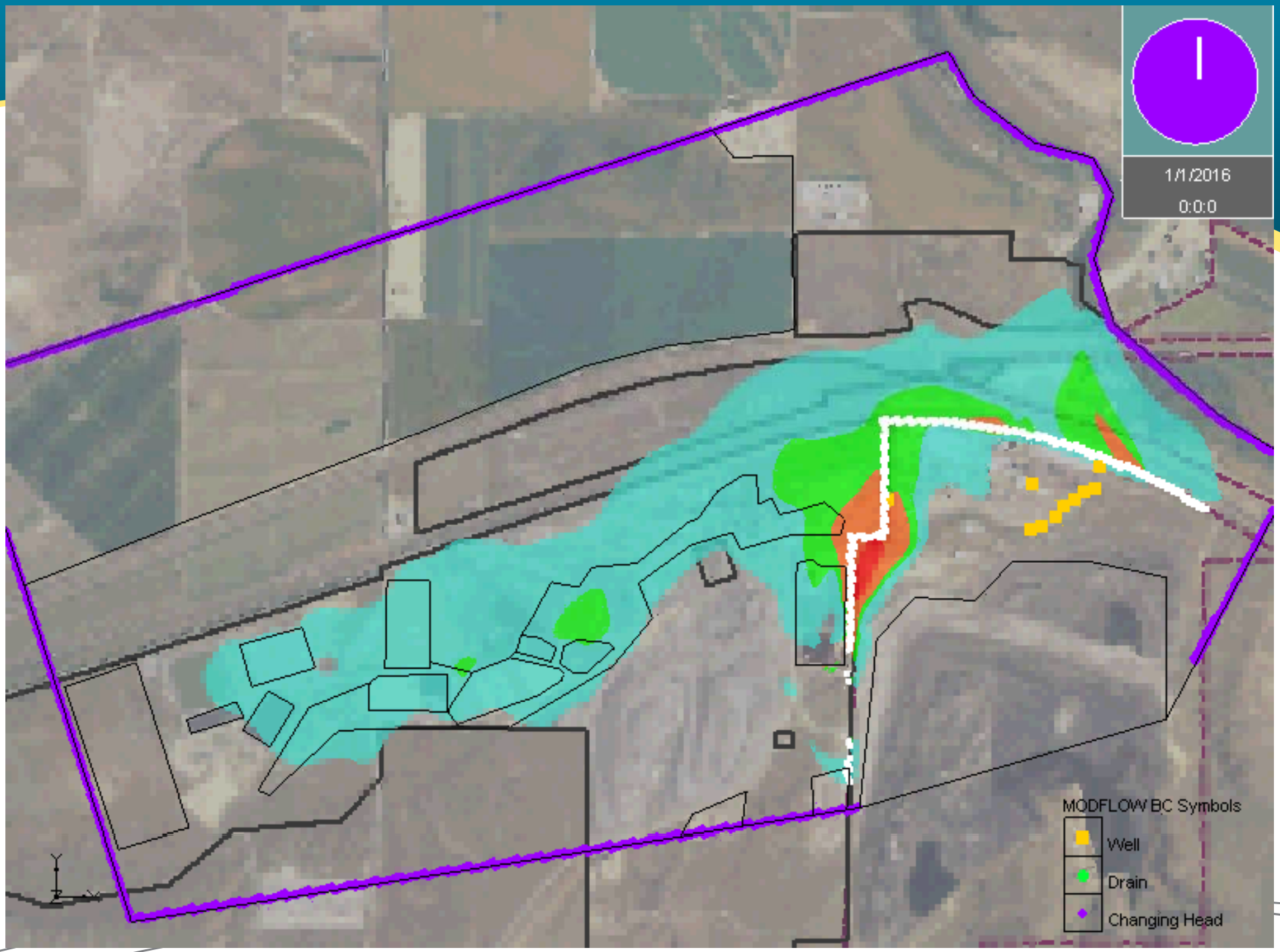


Alternative 1 – Arsenic at 100 Years

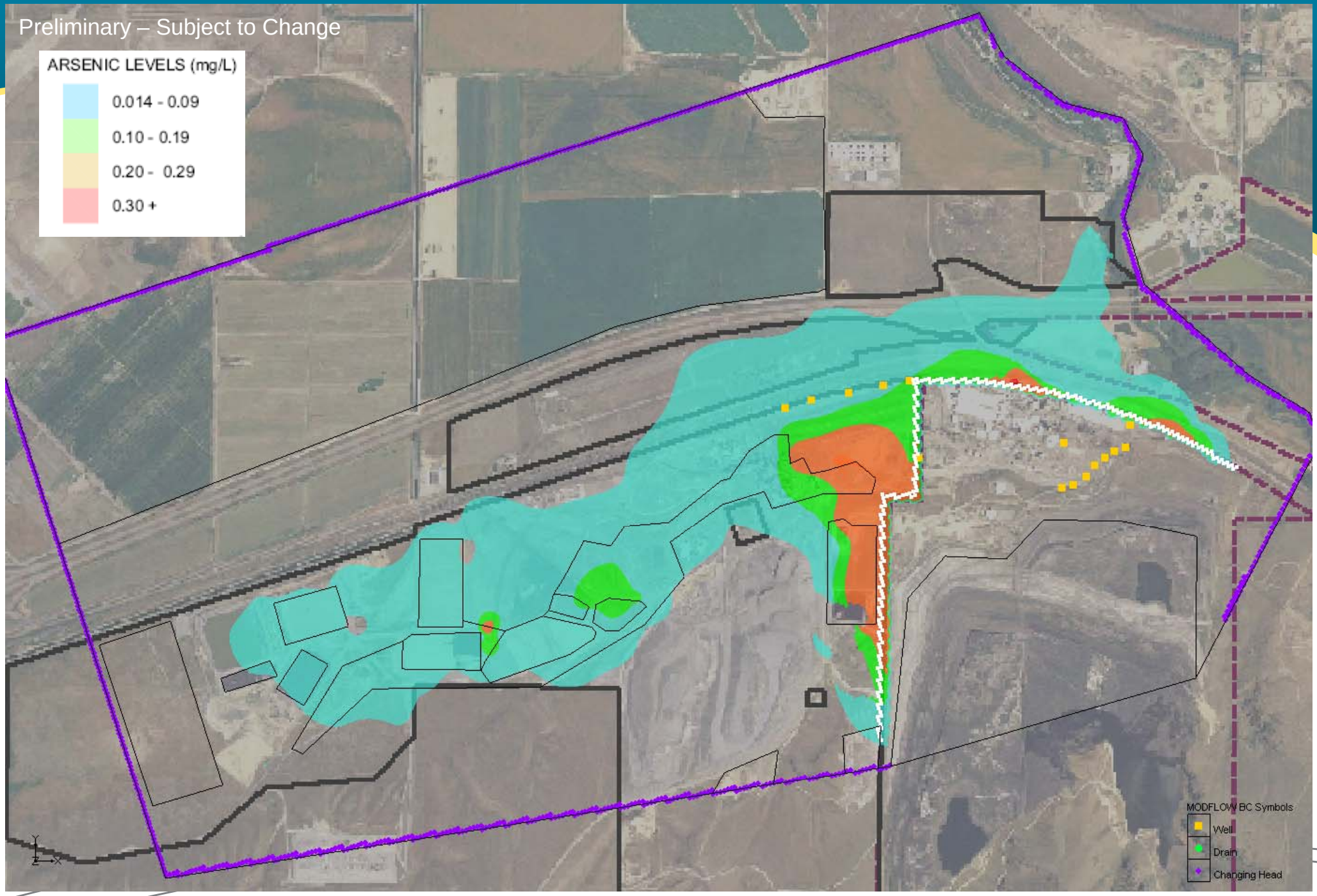


Alternative 1 Animation

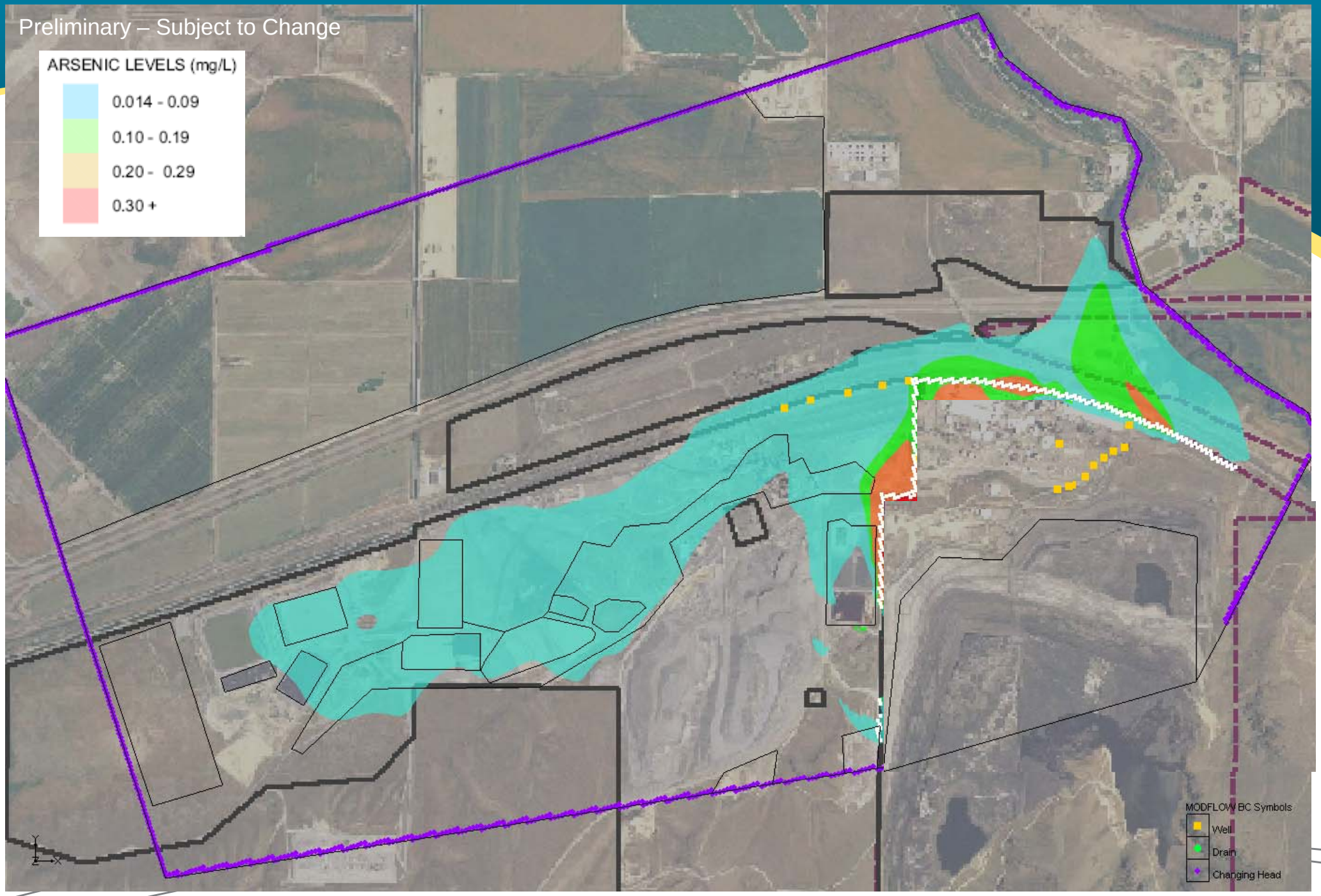
Preliminary – Subject to Change



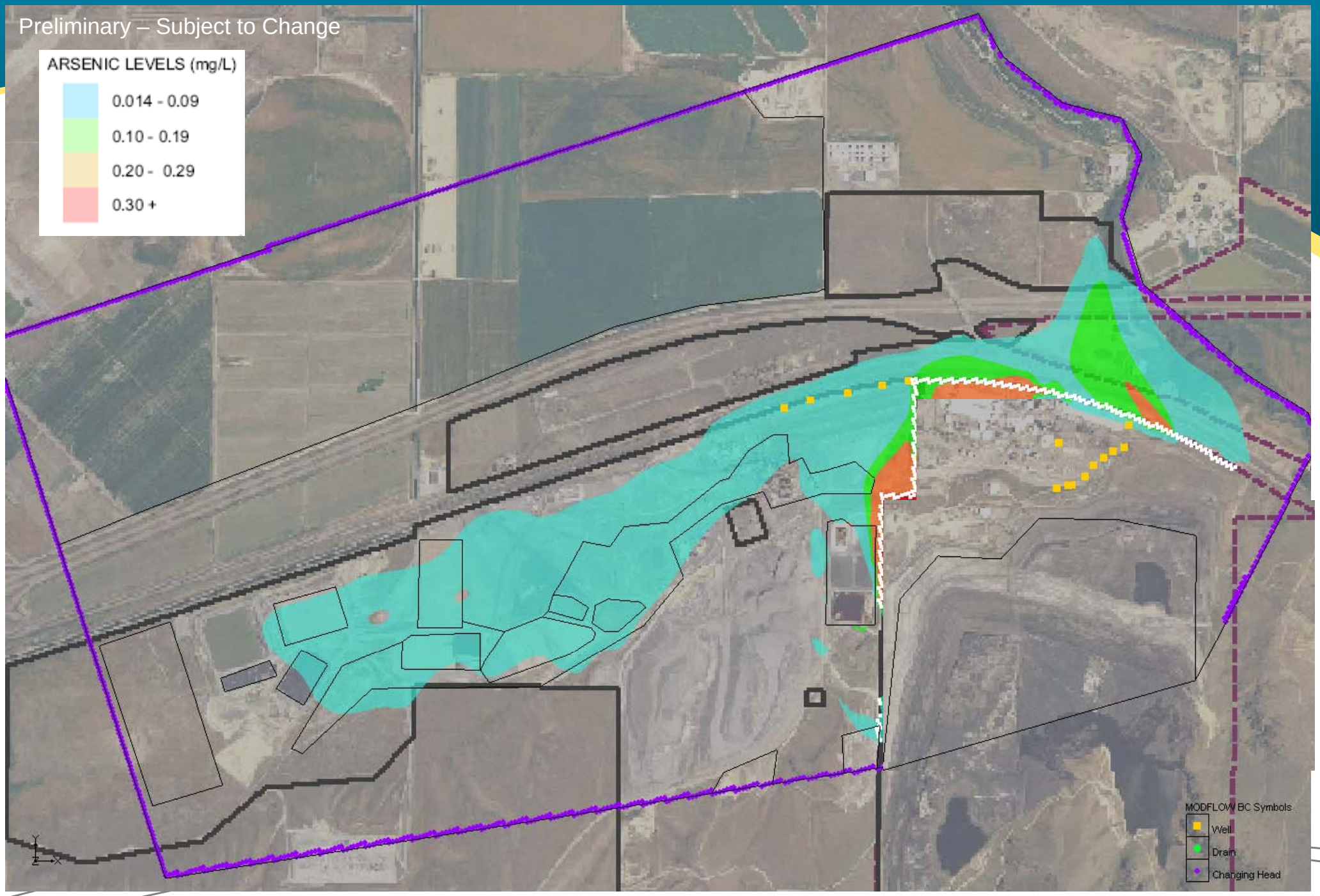
Alternative 2A – Arsenic Initial Condition



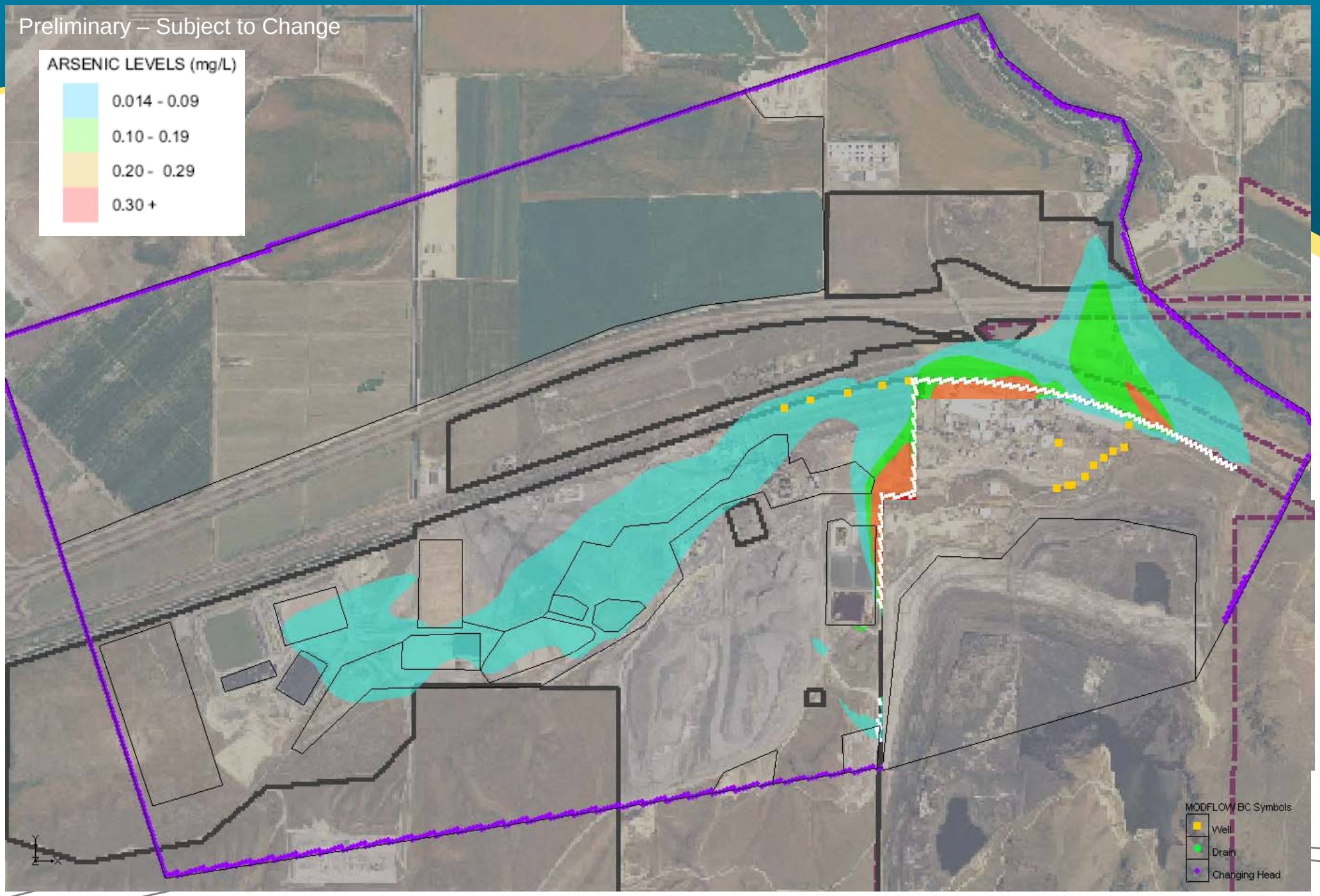
Alternative 2A – Arsenic at 25 Years



Alternative 2A – Arsenic at 50 Years

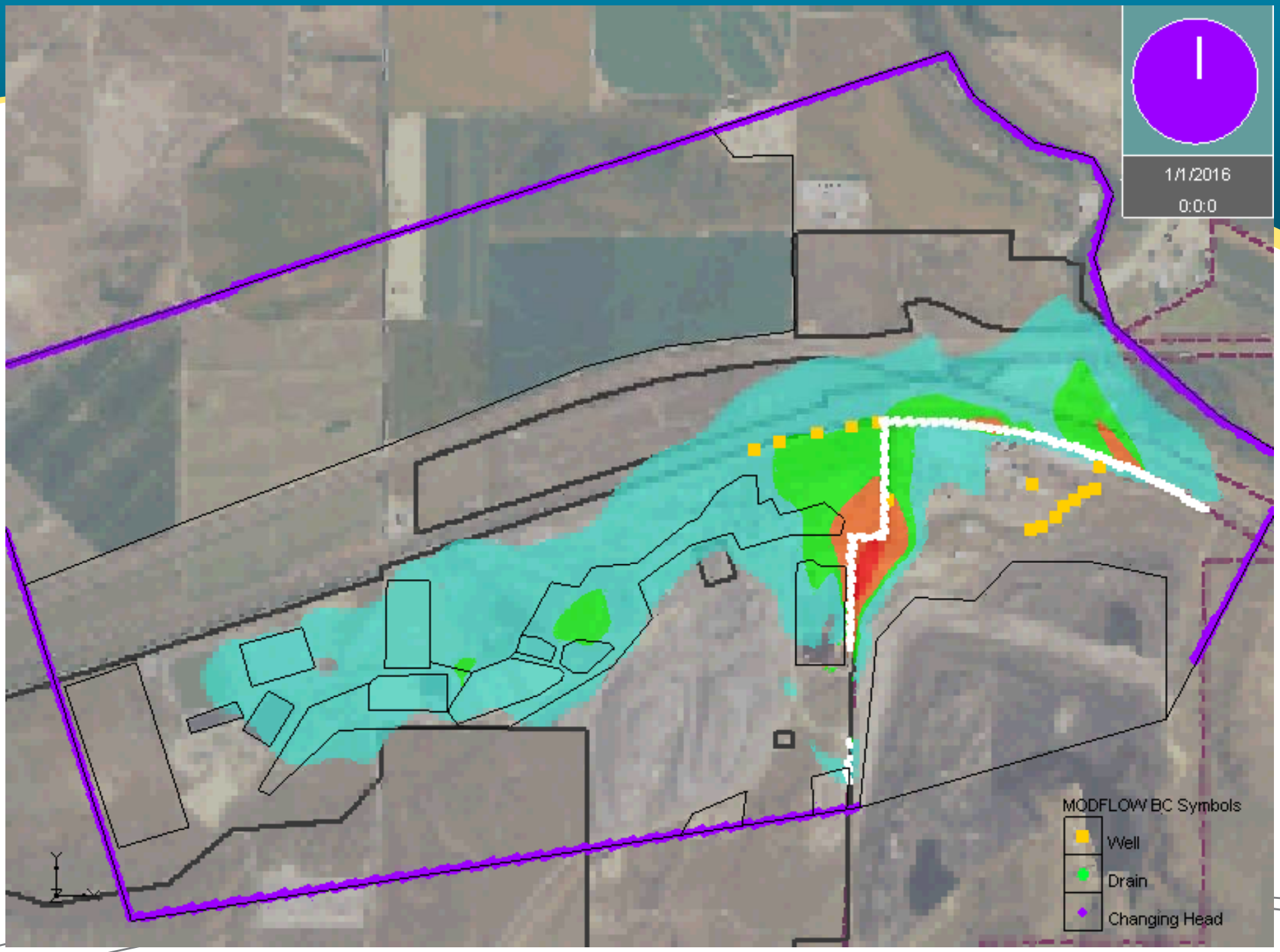


Alternative 2A – Arsenic at 100 Years

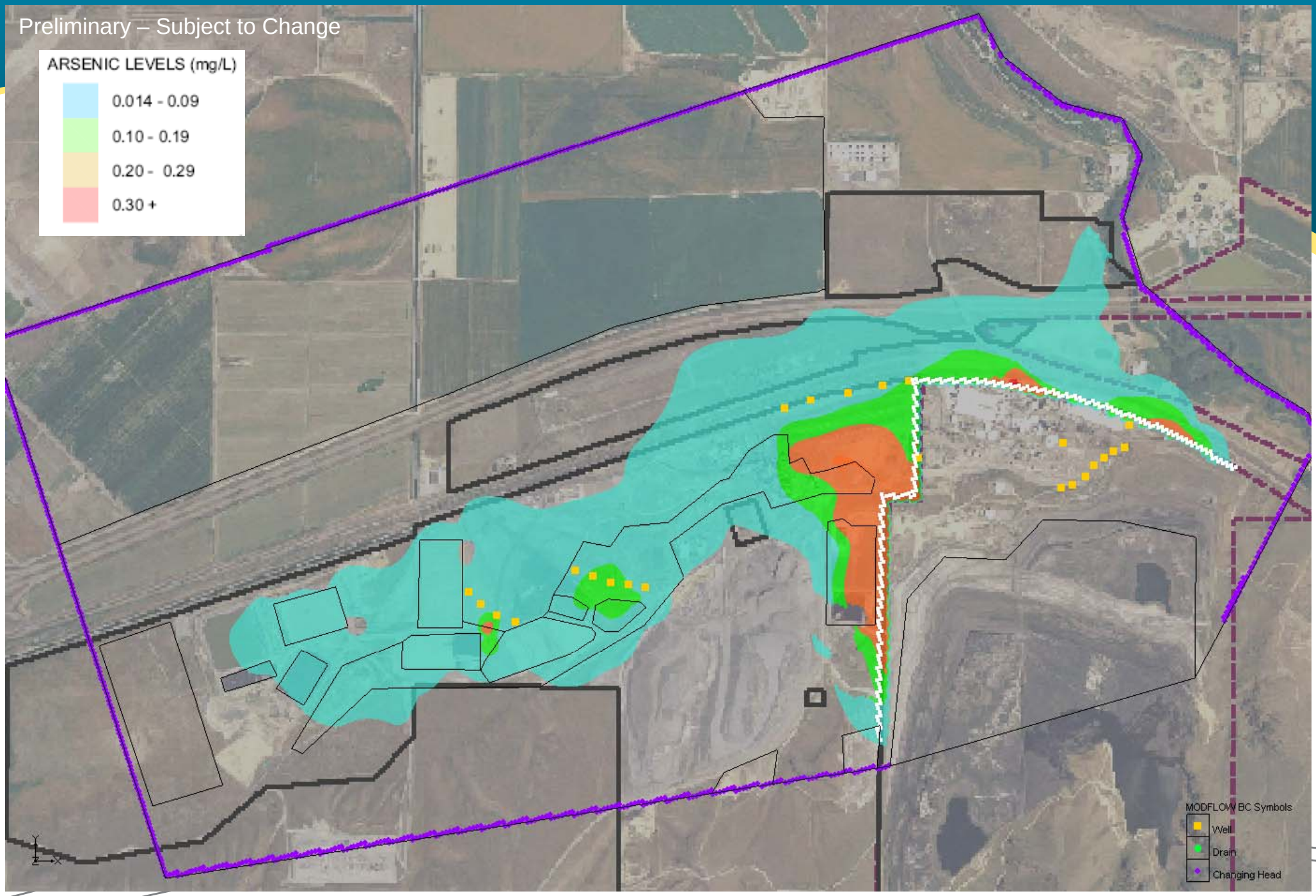


Alternative 2A Animation

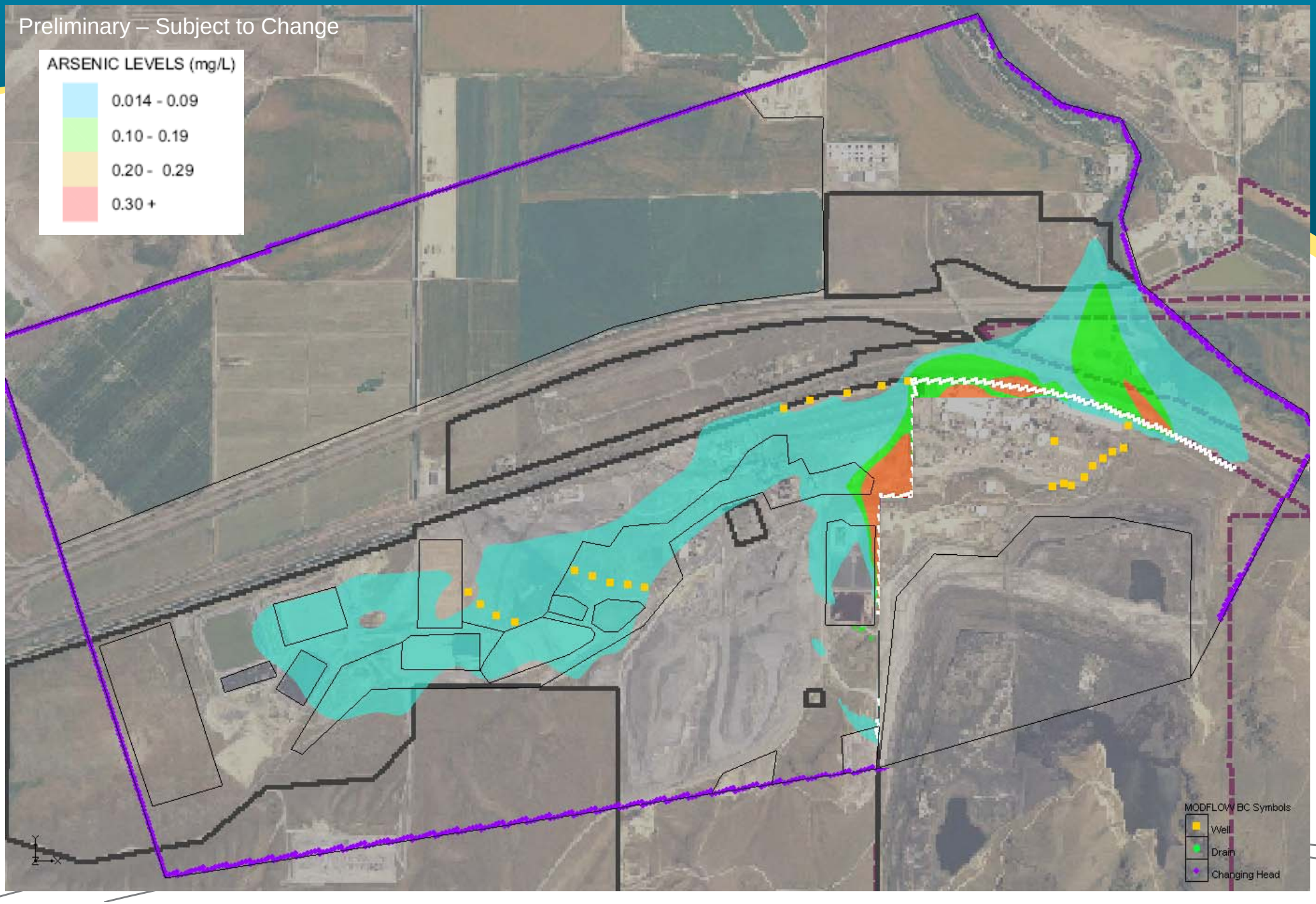
Preliminary – Subject to Change



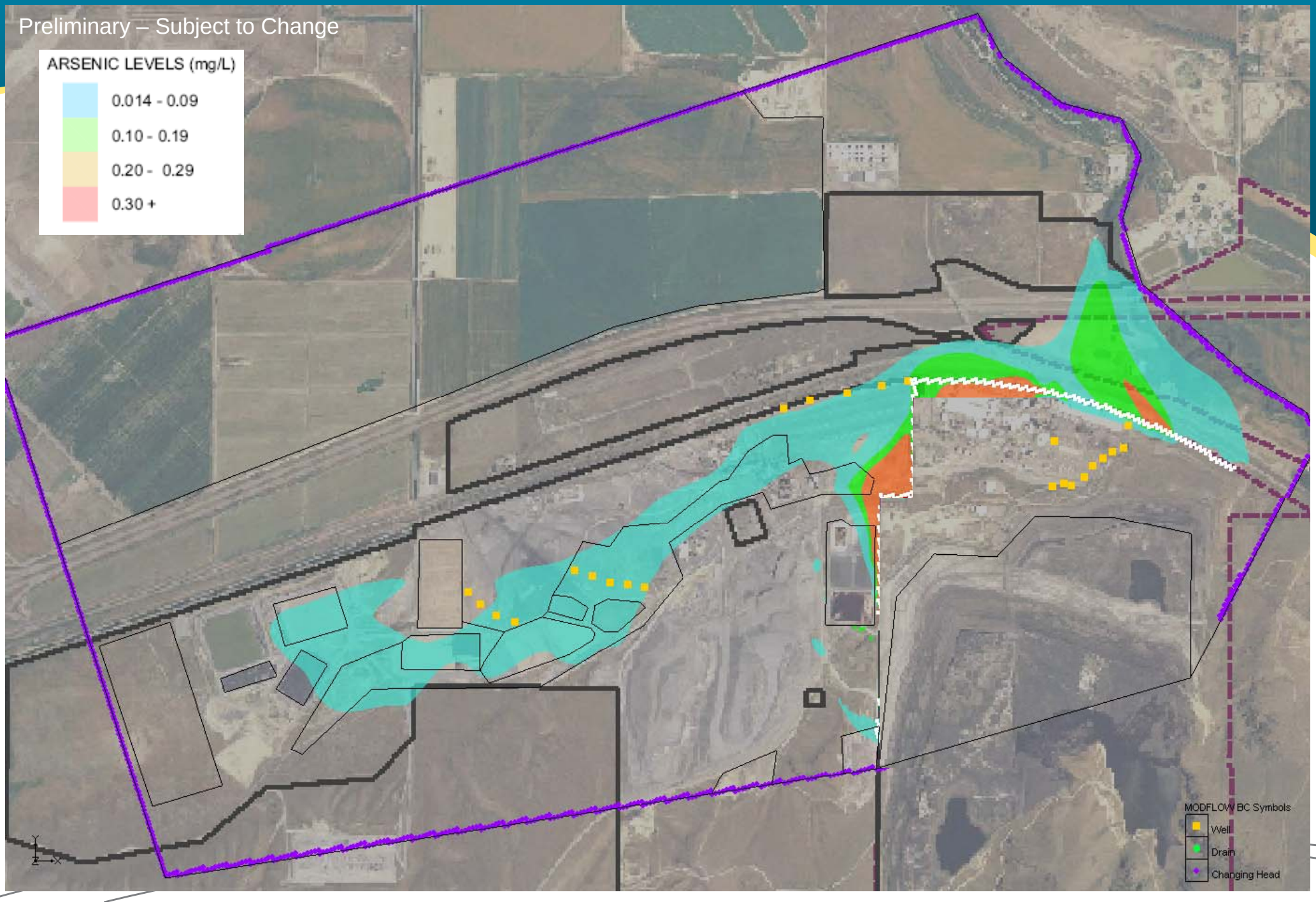
Alternative 3A – Arsenic Initial Condition



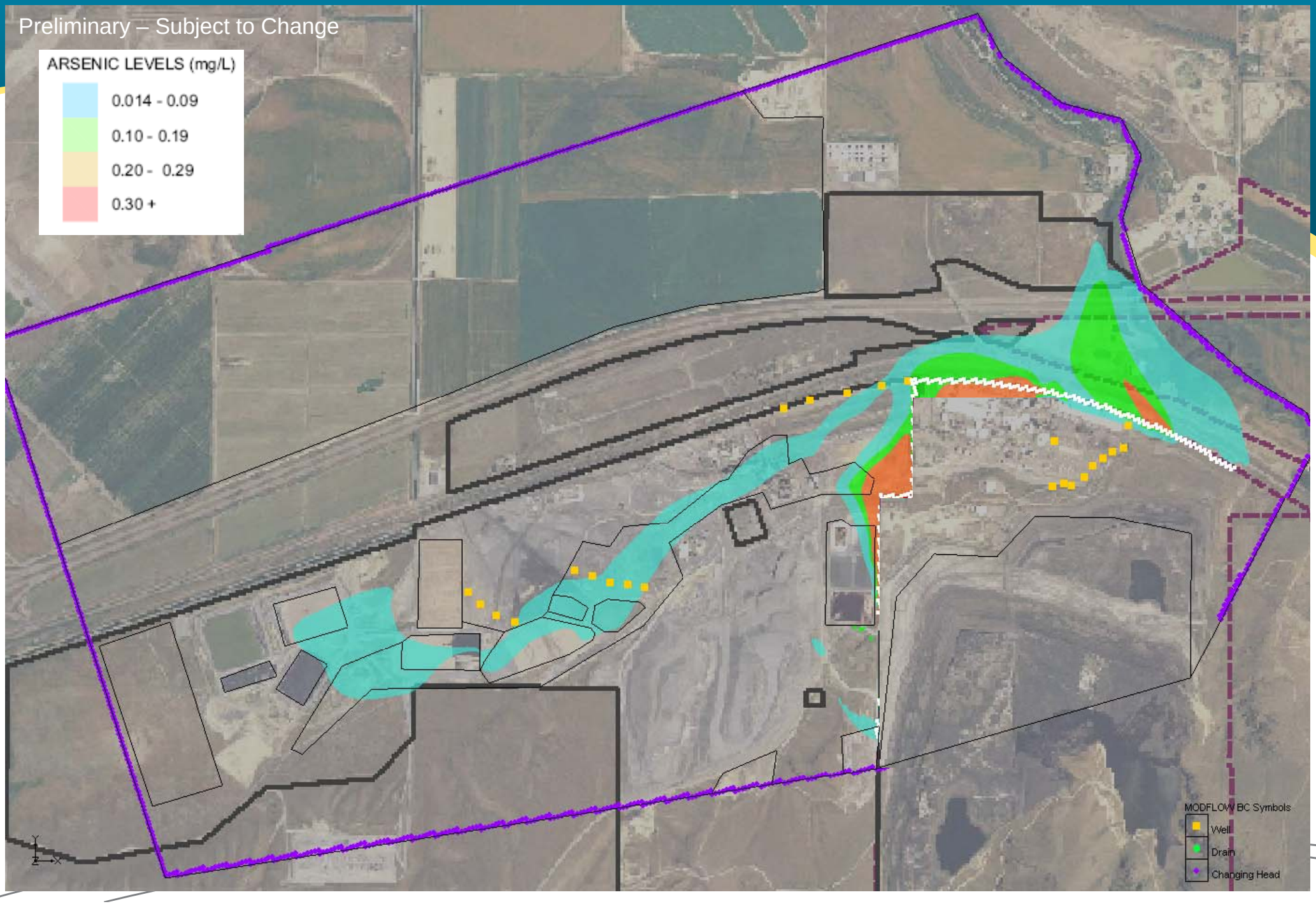
Alternative 3A – Arsenic at 25 Years



Alternative 3A – Arsenic at 50 Years

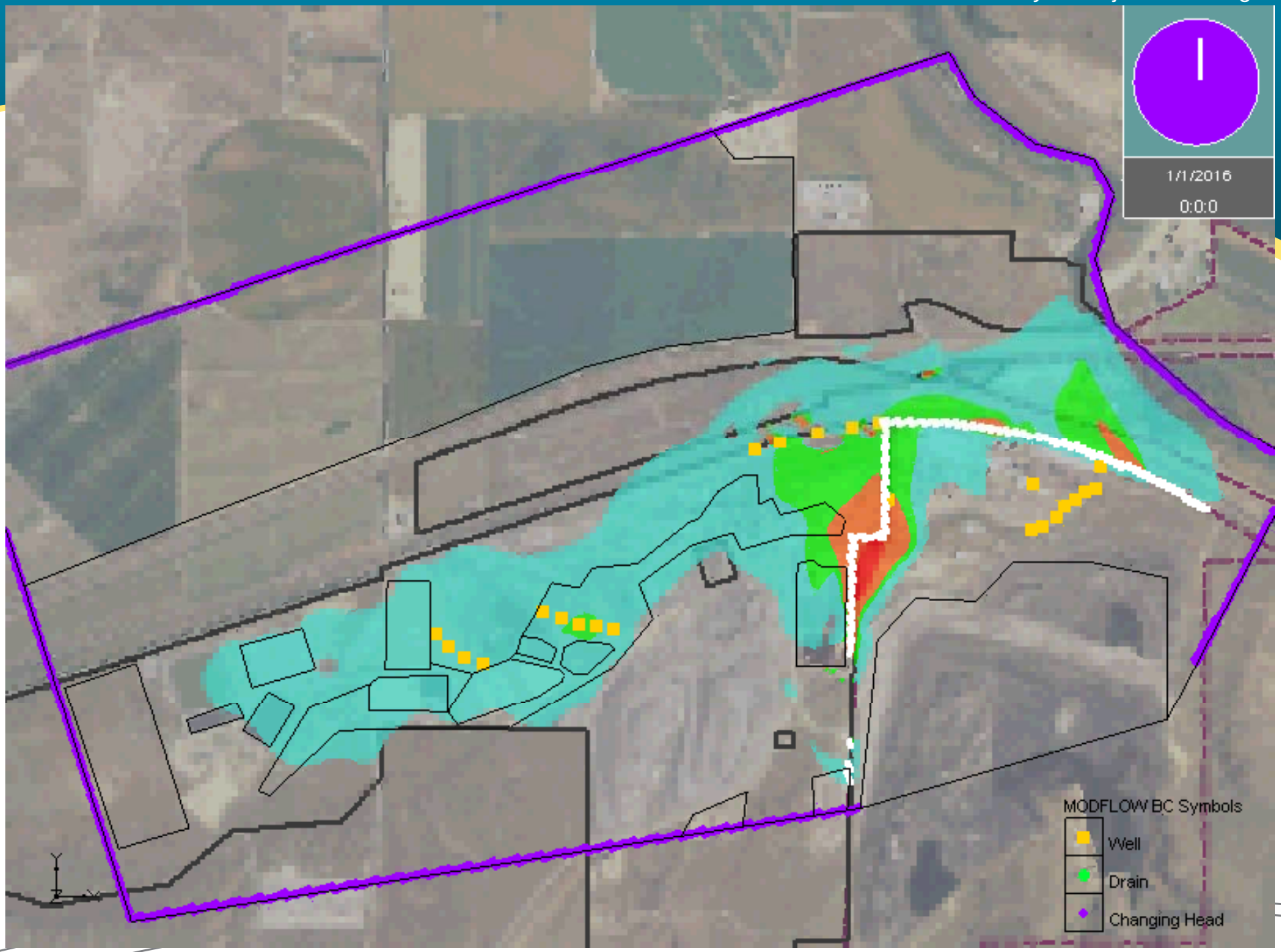


Alternative 3A – Arsenic at 100 Years



Alternative 3A Animation

Preliminary – Subject to Change



Sensitivity Analysis of Predictive Simulations

- Sensitivity runs refined based on results of calibration sensitivity analysis
  - $K_d/2$, $K_d x2$
  - D/5, Dx5
  - No porosity runs - transport model was found to be relatively insensitive to changes based on expected range of values

Conclusions

- Flow and transport model adequately calibrated to meet objective for evaluation of alternatives to support SFS
- Predictive simulations show none of the alternatives will achieve groundwater restoration RAO (arsenic MCL) within a reasonable time-frame (100 years)
- None of the sensitivity simulations achieved the groundwater restoration RAO (arsenic MCL) within a reasonable time-frame (100 years)

SFS Evaluation of Groundwater Alternatives

- All three alternatives meet “reduce the release…from facility sources” RAO through source controls (soil alternatives)
- All three alternatives meet “prevent potential ingestion…” RAO through ICs
- None of the alternatives meet “restore groundwater…” RAO in a reasonable timeframe
  - Technical Impracticability (TI) waiver?

Path Forward

- Agreement on GW alternatives for SFS evaluation
- Agreement on predictive simulations
- Prepare model report (presented as appendix to SFS report)
- Proceed with SFS evaluation

Rob Hartman

From: Rob Hartman
Sent: Monday, November 02, 2009 4:31 PM
To: 'Lynch.Kira@epamail.epa.gov'; 'Zavala.Bernie@epamail.epa.gov'; 'Scott.Miller@deq.idaho.gov'; 'Doug Tanner'; 'Kelly Wright'; 'Susan Hansen'; 'Fisher.Carla@epa.gov'; 'Ross.Randall@epa.gov'; 'mbeljin@cinci.rr.com'
Cc: 'Barbara Ritchie'; Marc Bowman; Douglas Oliver Jr.; Zachary Brown; 'Prouty, Alan L'; Andy Koulermos (akoulermos@FormationEnv.com)
Subject: Minutes from October 21 2009 FMC GW Modeling Meeting
Attachments: FMC SFS GW Model 21Oct09 Presentation.pdf; GW Flow Model Meeting Minutes 21Oct09.pdf

On behalf of FMC, I am routing a copy of the meeting minutes from the October 21, 2009 FMC Groundwater Modeling Meeting. The meeting presentation is also attached to the meeting minutes (and to this email).

Contact me if questions. Thank you, Rob.

Rob J. Hartman, P.G.
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Meeting Minutes
FMC Plant OU SFS Groundwater Modeling Meeting
Boise, Idaho
Conducted on October 21, 2009

Attendees:

U.S. EPA:	Kira Lynch, Bernie Zavala, Milovan Beljin(*), Randall Ross(*)
Idaho DEQ:	Scott Miller
FMC:	Barbara Ritchie
MWH:	Marc Bowman, Rob Hartman, Zak Brown, Doug Oliver

(*) via webcast/teleconference:

Key issues and discussion topics

The purpose of this meeting was to present the results of the predictive simulations (particle tracking and contaminant transport) of the SFS alternatives and discuss the path forward for the SFS.

Rob Hartman, Doug Oliver, and Zak Brown gave a presentation summarizing the results of the plume matching effort performed to calibrate the transport model, and predictive results for the SFS groundwater alternatives. The associated PowerPoint presentation was converted to a pdf and is attached.

The following paragraphs summarize the main issues, comments, and questions that were raised during this meeting (not necessarily in the order discussed):

Groundwater Alternative Details and Predictive Results

MWH/FMC presented the groundwater alternatives and results from predictive simulations generated with MODFLOW, MODPATH, and MT3D-MS to predict capture zones, contaminant transport flow directions/capture zones, and contaminant plumes through time. Results were presented for Groundwater Alternative 1 (which includes source controls and monitoring but no active groundwater extraction; monitored natural attenuation [MNA]), Groundwater Alternative 2 (hydraulic containment near the Plant Site boundary with five extraction wells), and Groundwater Alternative 3 (pump and treat with nine extraction wells in the former source areas and five extraction wells at the Plant Site boundary), Groundwater Alternative 3 was modified to include wells at the Plant boundary, based on discussions from the September 21st meeting. Alternatives 2 and 3 include two water treatment/disposal options denoted as 2A/3A (discharge to POTW) and 2B/3B (treat and discharge to evaporation/infiltration basins toward the west side of the FMC Plant Site). FMC/MWH has contacted the Pocatello Water Pollution Control Department (John Herrick, Superintendent) and requested an affirmation (or denial) of their capability and capacity to accept the preliminary estimated flows associated with Alternatives 2 and 3 flows over the long term.

Initial contaminant concentrations for the predictive simulations were based on measured 2006-2008 data published in the Groundwater Current Conditions Report and Simplot's 2008 quarterly groundwater monitoring reports. Initial concentrations in layer 1 and 2 were set based on data from wells in the upper aquifer and initial concentrations in layers 3 and 4 were set based on data from wells in the deeper aquifer.

Particle tracking for Alternatives 2 and 3 included both forward tracking (particles released throughout arsenic plume in layers 1, 2, and 3 and color-coded by layer) and backward tracking (particles released in layer 2 at extraction wells and color-coded based on layer where particles exit the domain). The color code for the presentation particle track figures is: Layer 1 = pink, Layer 2 = blue, Layer 3 = green, Layer 4 = yellow.

Contaminant plumes predicted through time (0, 25, 50, and 100 years) were presented for arsenic in layer 2 for the three groundwater alternatives. Video animation of the predictive runs through 100 years for arsenic in layer 2 for the three alternatives were also shown during the meeting, but would not transmit through the webcast.

The predictive simulations indicate that arsenic concentrations within the overall plume decrease relatively rapidly within 25 years and the width of the plume decreases (narrows) over the 100 year time frame. However, the overall length (parallel to flow direction) of the arsenic plume beneath the Plant Site is comparable for all three alternatives after 100 years. The residual arsenic plume remains in low hydraulic conductivity areas (layer 1 and layer 2) in the western ponds area and extending in the downgradient flow direction toward the northeastern Plant Site boundary. The predicted residual arsenic plume beneath the western ponds and extending to the Plant Site boundary is not due to the model assumption related to Simplot sources / pumping. Zak Brown noted that 1) the predictive runs for total phosphorus / orthophosphate and potassium show results similar to arsenic and 2) the predictive runs out to 400 years for all three alternatives still did not indicate any of the alternatives would achieve complete restoration of groundwater at the Plant Site to below the arsenic MCL.

Kira asked if there was a sensitivity run in which the recharge rate for the areas proposed for ET caps (modeled with recharge rate of 0.05 inch/year) in Soil Alternative 2 are assumed to be capped with RCRA covers (recharge rate 2×10^{-5} inch/year). Zak replied that sensitivity based on changes in assumed infiltration rate through the soil remedial alternative areas had not been run. FMC/MWH agreed to provide a discussion of the infiltration rate assumptions for the soil remediation areas in the sensitivity analysis section of the groundwater model report.

The EPA hydrogeologists (Randall, Milovan, and Bernie) commented that uncertainty in the transport model inputs renders the model unsuitable for use in predicting 'absolute' restoration times. However, the model is sufficient for use in the alternatives evaluation for the SFS.

Discussion of SFS Evaluation and Path Forward

The group then discussed the path forward for the project. Kira outlined several possible approaches for the groundwater remedial action which include:

- TI Waiver (possible for GW Alternatives 1, 2, or 3);
- Interim ROD (IROD) for groundwater with Final ROD for soil (possible for GW Alternatives 2 or 3); and,
- Final ROD for groundwater with RCRA Waste Management Unit defined (possible for GW Alternatives 2 or 3).

The TI waiver and process would be significantly different depending on the groundwater alternative selected. For example, the TI waiver would require a significant effort if GW Alternative 1 is selected. Justifying a TI waiver for any of the alternatives (particularly GW Alternative 1 – MNA), would be a significant undertaking relative to that effort required for the IROD. The IROD approach is not appropriate for GW Alternative 1 (MNA), because groundwater is not contained.

Through an IROD, the "reasonable time-frame" requirement does not need to be met. The benefit of an IROD is that it leaves the option open to turn off the pumping system at a later date if pumping is not effective. The effectiveness of the pumping would be evaluated every five years under an IROD (or ROD). Another advantage of the IROD is that there is no time requirement for the IROD to go to a final ROD.

TI waiver requires rationale to define and justify the area set for the TI zone. As a result, justifying TI for GW Alternative 2 (Containment) and 3 (Pump and Treat) will be substantially easier than for GW Alternative 1 (MNA). The evaluation of GW alternatives in the SFS should focus on the differences between the alternatives, specifically differences in implementability (e.g., pumping in low hydraulic conductivity material) and acceptance.

If GW Alternative 2 or 3 is selected, the ROD should define the performance objectives for the pumping system, but not specify pumping rates. Evaluation of hydraulic containment systems should follow the EPA guidance (A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems, U.S. EPA, 2008)

Kira stated that a lot of the RODs that have been issued in the past have misinterpreted the NCP guidelines. The NCP states a preference for restoration. Furthermore, most of the TI waivers issued have been for DNAPL sites. Rob noted the Butte Priority Soils Operable Unit (BPSOU) ROD includes a TI waiver for metals (including arsenic) in the shallow alluvial groundwater and asked for assistance from Kira and Bernie in obtaining a copy of the EPA TI evaluation and response to comments documents for the BPSOU. Kira stated that she and Bernie are attending an EPA conference on groundwater and that the conference will include 3 groundwater TI sites. Kira and Bernie will provide relevant TI documents as available.

Doug asked how sustainability should/can be considered in the FS process. Kira responded that Region 10 is developing guidance but has not finalized / issued as yet. In summary, the guidance suggests that sustainability is not used to differentiate between alternatives, but it can and should be used when evaluating process options. For example, sustainability should be considered when evaluating water treatment/disposal options (to differentiate between GW Alternatives 2A and 2B).

Schedule

The Draft SFS is still on schedule to be submitted in mid-December 2009. The groundwater modeling report will be submitted with the Draft SFS, but FMC/MWH will evaluate possibility of submitting the groundwater modeling report in advance of the Draft SFS and will advise EPA if accelerated submittal is possible.

Action Items

During the FMC groundwater model review meeting on October 21, 2009, we captured the following list of action items:

1) Provide a copy of the meeting presentation slides to the "FMC groundwater model group" distribution list. **Follow-up:** Meeting presentation slides were routed via email to the agency distribution list on October 22.
2) EPA will work to obtain and provide the BPSOU TI documents and the ESTCP/SERDP study of groundwater exit strategies (in review).
3) FMC/MWH will evaluate opportunity to accelerate submittal of the Groundwater Modeling Report and advise the agency route list.

APPENDIX B
EMF REMEDIAL INVESTIGATION TABLES AND FIGURES

TABLE 3.3-1

HYDRAULIC CONDUCTIVITIES AND TRANSMISSIVITIES OF EMF AQUIFER SYSTEM

TABLE 3.3-1

	Shallow Wells	Hydraulic Conductivity cm/s	Hydraulic Conductivity ft/day	Type of Test	Source
MICHAUD FLATS	104	4.45E-02	126	Slug Test	BEI
	108	1.01E-01	286	Slug Test	BEI
	110	3.80E-02	108	Slug Test	BEI
	111	1.40E-01	397	Slug Test	BEI
	113	1.40E-01	397	Pumping Test	BEI
	126	5.85E-02	166	Slug Test	BEI
	134	1.09E-01	309	Slug Test	BEI
	135	3.15E-02	89.3	Slug Test	BEI
	139	1.90E-02	53.9	Slug Test	BEI
	140	9.70E-02	275	Slug Test	BEI
	146	6.10E-02	173	Slug Test	Hydrometrics
	148	2.45E-02	69.5	Slug Test	Hydrometrics
	150	3.55E-01	1000	Pumping Test	BEI
	153	3.30E-01	935	Slug Test	BEI
	154	1.74E-02	49.3	Slug Test	Hydrometrics
	501	9.05E-02	257	Slug Test	BEI
	514	3.92E-02	111	Slug Test	Hydrometrics
	515	1.05E-02	29.8	Slug Test	Hydrometrics
	516	2.33E-02	66.0	Slug Test	Hydrometrics
BANNOCK RANGE	106	4.30E-03	12.2	Slug Test	Hydrometrics
	142	7.00E-04	1.98	Slug Test	BEI
	300	2.43E-04	0.69	Slug Test	Hydrometrics
	301	1.00E-05	0.03	Slug Test	BEI
	304	4.95E-04	1.41	Slug Test	Hydrometrics
	306	1.17E-03	3.32	Slug Test	Hydrometrics
	307	9.91E-02	281	Slug Test	Hydrometrics
	308	2.51E-02	71.2	Slug Test	Hydrometrics
	313	1.80E-02	51.0	Slug Test	BEI
	316	1.02E-02	28.9	Slug Test	BEI
	323	1.20E-03	3.40	Slug Test	Hydrometrics
	325	5.45E-03	15.5	Slug Test	BEI
	333	9.91E-03	28.1	Slug Test	Hydrometrics
	PEI-2	1.00E-03	2.83	Pumping Test	PEI
	PEI-5	4.50E-04	1.28	Pumping Test	PEI
PORTNEUF RIVER	312	1.40E+00	3970	Pumping Test	BEI
	318	1.40E-03	3.97	Slug Test	BEI
	324	5.45E-02	154	Slug Test	BEI
	327	1.18E-01	334	Slug Test	Hydrometrics
	328	1.84E-01	522	Slug Test	Hydrometrics
	502	1.39E-01	394	Slug Test	Hydrometrics
	503	1.68E+00	4760	Slug Test	BEI
	505	3.66E-01	1038	Slug Test	Hydrometrics
	507	6.40E-01	1810	Slug Test	BEI
	517	7.20E-01	2040	Slug Test	BEI
	518	1.49E-01	422	Slug Test	Hydrometrics

	Deep Wells	Hydraulic Conductivity cm/s	Hydraulic Conductivity ft/day	Type of Test	Source
MICHAUD FLATS	103	5.20E-03	14.7	Slug Test	BEI
	107	2.20E-02	62.4	Slug Test	BEI
	109	5.15E-03	14.6	Slug Test	BEI
	125	7.22E-02	205	Slug Test	Hydrometrics
	133	1.20E-01	340	Slug Test	BEI
	145	2.15E-01	609	Slug Test	BEI
	500	6.70E-02	190	Slug Test	BEI
BANNOCK RANGE	315	1.19E-02	33.7	Slug Test	BEI
PORTNEUF RIVER	311	8.60E-04	2.44	Slug Test	BEI
	317	9.90E-03	28.1	Slug Test	BEI
	319	1.00E-02	28.4	Slug Test	BEI
	321	1.50E-01	425	Slug Test	BEI
	322	2.80E-01	794.7	Pumping Test	BEI
	329	3.65E-01	1030	Slug Test	BEI
	330	5.64E-02	160	Slug Test	Hydrometrics
	504	7.10E-02	201	Slug Test	Hydrometrics
	506	2.30E-01	652	Slug Test	BEI
	512	5.80E-01	1640	Slug Test	BEI
	519	1.59E-02	45.0	Slug Test	Hydrometrics

	Production Wells	Transmissivity (ft^2/day)	Transmissivity (gpd/ft)	Type of Test	Source
MICHAUD FLATS	FMC-6	7370	55130	Pumping Test	BEI
	32ACD1	35100	262550	Pumping Test	USGS
	32DDC1	135700	1015000	Pumping Test	USGS
	33BAA1	21900	163810	Pumping Test	USGS
	33CCD1	41400	309670	Pumping Test	USGS
	34ADD1	40400	302190	Pumping Test	USGS
	34DCC1	36600	273770	Pumping Test	USGS
	35DDC1	164400	1229700	Pumping Test	USGS
	3ACD1	41200	308176	Pumping Test	USGS
	3BDC1	444000	3321100	Pumping Test	USGS
	4BBA1	38500	287980	Pumping Test	USGS
	5BDA1	36800	275260	Pumping Test	USGS
	8ADA1	27300	204200	Pumping Test	USGS
	9CAC1	199000	1488500	Pumping Test	USGS
	12BBC1	54700	409160	Pumping Test	USGS
PORTNEUF RIVER	SWP-7	227270	1700000	Pumping Test	Simplot

References:
BEI = Bechtel Environmental, Inc., Preliminary Site Characterization Summary for the Eastern Michaud Flats site, January, 1994
PEI = PEI Associates, Inc., Evaluation of Waste Management for Phosphate Processing, April 1985
Hydrometrics = Hydrometrics, Inc., Hydraulic Conductivity Testing of Existing Well Sites at the Eastern Michaud Flats Site, Pocatello, Idaho, April 1994
USGS = United States Geological Survey, Water-Resources Investigations Report 84-4201, Hydrogeology of Eastern Michaud Flats, Fort Hall Indian Reservation, Idaho
Simplot = J.R. Simplot files
FMC = FMC files

Hydraulic conductivity at Well 318 not used in K-zone mapping due to potential precipitation reactions in formation related to mixing of low pH water with groundwater.
Transmissivity at Well 311 not used due to possible grout contamination in filter pack.

Table 4.2.3-3

Table 4.2.3-3
Constituents in Wastewater and Sediments

Sample Source	Sample ID	Sample type	Alkalinity, Bicarbonate (mg/l)	Alkalinity, Carbonate (mg/l)	Aluminum (*)	Ammonia (NH_3 as N) (mg/l)	Antimony (*)	Arsenic (*)	Barium (*)	Beryllium (*)	Boron (*)	Cadmium (*)	Calcium (*)	Chloride (*)	Chromium (*)	Cobalt (*)	Copper (*)	Fluoride (*)	Gross Alpha (**)	Gross Beta (**)
Calciner Pond Influent	FSWCPW01	PSL	541	1 U	9.24 J	268	1.92 J	3.977 J	0.26	0.001 UJ	2.89	0.818	154 J	3750	0.133 J	0.038 U	0.223	134	642	17700
IWW Ditch	FSWIWW01	PSL	324	1 U	7.66 J	288	1.28 UJ	1.759 J	0.27	0.001 UJ	4.53	0.0341 J	141 J	1620	0.02 UJ	0.027 U	0.163	61.6	155	6890
Discharge to Pond 8E	FSWPS88E	PSL	4420	1 U	715 J	39.6	7.12 J	0.04863 J	9.45	0.114	0.19	1.66	114 J	740	2.03 J	0.09	13.39	1510	668	6480
Discharge to Phase IV Ponds	FSWPWSIV	PSL	1640	1 U	2.36 J	29.7	0.94 UJ	0.1454 J	0.04	0.001 UJ	0.18	0.02364 J	30.4 J	307	0.413 J	0.034 U	0.032	436	21.8	2420
Phossy Water Discharge to Pond 8S	FWWP8S01	PSL						0.6168 J												
Railroad Swale Composite	FWWRRS01	PSL	143	1 U	9.83 J	1.3	0.06 UJ	0.00832 U	0.22	0.001 UJ	0.41	0.15206	73.6 J	274	0.02863 J	0.044 U	0.139	4.2	48.3	30.1
Calciner Pond Sediment	FSDCPW01	PSW			11400		59.2 J	6.7 UJ	94.6	1.3	2640	426 J	284000		531	1.7 U	58.9	191000	225 J	111
IWW Ditch Sediments	FSDIWW01	PSW			12800		82.8 UJ	38 J	886	1.6 U	50.1	267 J	121000		582	57	1920	7460	116 J	73.4
IWW Ditch Sediments	FSDIWW02	PSW			18200		53.3 UJ	17.5 J	591	1.4 U	44.5	139 J	161000		377	34.6	890	8560	131 J	81.1
IWW Ditch Sediments	FSDIWW03	PSW			13800		39.6 UJ	25 J	650	1.4 U	50	245 J	76900		418	52.6	1430	6320	202 J	134
IWW Ditch Sediments	FSDIWW04	PSW			10700		29.3 UJ	9.2 J	645	0.71 U	27.9	112 J	72800		218	34.3	687	5880	149 J	99
IWW Ditch Sediments	FSDIWW05	PSW			12900		37.6 UJ	20.8 J	1530	1.3 U	52.1	569 J	114000		677	62.2	2440	11400	299 J	129
IWW Ditch Sediments	FSDIWW06	PSW			9320		25.3 UJ	13.3 J	467	0.65	36.2	234 J	107000		275	56.9	1050	9140	222 J	105
Railroad Swale Sediments	FSDRRS01	PSW			21800		43.7 UJ	21.1 J	333	2.7	108	318 J	391000		737	4.6	168	29500	155 J	72
Coke Settling Pond Sediments	FWSCSP01	PSW			718		13.9 U	0.49 UJ	25.5	0.18 U	11.7 J	2.6	3930	219	8.2	0.9	7.3 J	228	4.51 UJ	3.76 UJ

Sample Source	Sample ID	Sample Type	Iron (*)	Lead (*)	Lead-210 (pCi/g)	Lithium (*)	Magnesium (*)	Manganese (*)	Mercury (*)	Molybdenum (*)	Nickel (*)	Nitrate (NO_3 as N) (*)	Orthophosphate (PO_4 as P) (*)	pH	Phosphorus, Total (*)	Potassium (*)	Potassium-40 (pCi/g)	Radium-226 (pCi/l)	Radium-228 (pCi/l)	Selenium (*)
Calciner Pond Influent	FSWCPW01	PSL	7.06 J	0.3258 J		2.216	14.7 J	0.211	0.0001 UJ	0.31	0.339	27.9	3930	4.67	5340	19330 J		0.34 UJ	-0.4 U	2.785 J
IWW Ditch	FSWIWW01	PSL	4.99 J	0.001 UJ		1.599	22 J	0.187	0.0001 UJ	0.19	0.17	18.4	2210	7.12	2590	7470 J		0.72 UJ	-0.2 U	4.217 J
Discharge to Pond 8E	FSWPS88E	PSL	197.1 J	0.5472 J		1.664	19.6 J	11.63	0.00027	0.27	2.454	0.39	1360	10.47	7680	9890 J		103	-2.7 U	0.2069 J
Discharge to Phase IV Ponds	FSWPWSIV	PSL	2.156 J	0.001 UJ		0.537	13.3 J	0.204	0.0001 UJ	0.017 U	0.007 UJ	0.6	782	7.99	1370	2890 J		1.9 J	-2.4 U	0.2292 J
Phossy Water Discharge to Pond 8S	FWWP8S01	PSL																		
Railroad Swale Composite	FWWRRS01	PSL	8.44 J	0.00599 UJ		0.057	14.8 J	0.16	0.0001 UJ	0.03 U	0.066	1.2	4.24	10.16	21.3	19.6 J		1.59	-0.3 U	0.0104 J
Calciner Pond Sediment	FSDCPW01	PSW	5440 J	30.9 UJ	1.72 U	23.1 UJ	4730	91.8	0.31 UJ	32.5 U	79		13200	5.02	91000	79800	70.4			3.8 UJ
IWW Ditch Sediments	FSDIWW01	PSW	19300 J	96.3 UJ		13.1 UJ	10500	1220	4 J	14 U	99.6		1490	7.68	42600	3180				28.4 J
IWW Ditch Sediments	FSDIWW02	PSW	14600 J	46.9 UJ		15.7 UJ	10900	1190	4.5 J	9 U	88.3		1040	8.15	38200	4310				14.7 J
IWW Ditch Sediments	FSDIWW03	PSW	14300 J	82 UJ		11.8 UJ	9030	1260	6 J	8.5 U	72.6		915	7.55	28100	3340				11 J
IWW Ditch Sediments	FSDIWW04	PSW	10300 J	38.9 UJ		9.6 UJ	7770	4400	1.2 J	4.9 U	62		391	8.13	22700	2510				7.1 UJ
IWW Ditch Sediments	FSDIWW05	PSW	18200 J	137 J		11.9 UJ	6780	3950	2.8 J	13.8 U	121		1560	7.87	45300	3340				17.6 J
IWW Ditch Sediments	FSDIWW06	PSW	10100 J	50.8 UJ		8.2 UJ	6230	1500	2.1 J	10.3 U	68.1		289	8.65	40400	2190				12.7 J
Railroad Swale Sediments	FSDRRS01	PSW	11400 J	26.7 UJ		17.4 UJ	6470	253	0.96 UJ	18.5 U	126		1760	8.94	123000	6700				13.8 J
Coke Settling Pond Sediments	FWSCSP01	PSW	2570	5.7 J	6.64 U	9.1 U	371	49.6	0.24	3.6 U	9.1 U	0.94	15.9	9.4	306	192	0.926 UJ			1.4 U

Sample Source	Sample ID	Sample Type	Silver (*)	Sodium (*)	Specific Conductance (umhos/cm)	Sulfate (*)	Temperature (°C)	Thallium (*)	Total Dissolved Solids (mg/l)	Uranium-238 (pCi/g)	Vanadium (*)	Zinc (*)
Calciner Pond Influent	FSWCPW01	PSL	0.058	3990 J	3500	19800	37.77778	0.176 J	64000		1.14	10.13
IWW Ditch	FSWIWW01	PSL	0.035	1450 J	130	8400	25.33333	0.318 J	7460		0.83	5.25
Discharge to Pond 8E	FSWPS88E	PSL	2.45	1449 J	1206	33	19.83333	0.001 UJ	22100		15.62	5210
Discharge to Phase IV Ponds	FSWPWSIV	PSL	0.007 U	598 J	375	2 U	23.05556	0.001 UJ	10100		0.37	41.8
Phossy Water Discharge to Pond 8S	FWWP8S01	PSL										
Railroad Swale Composite	FWWRRS01	PSL	0.01 U	179 J	1900	79	19.88889	0.001 UJ	1070		0.77	1.58
Calciner Pond Sediment	FSDCPW01	PSW	25.1	20300				50.35		17.5	607	6000 J
IWW Ditch Sediments	FSDIWW01	PSW	58.1	3990				129.1			423	6780 J
IWW Ditch Sediments	FSDIWW02	PSW	14.7	3200				83			366	2930 J
IWW Ditch Sediments	FSDIWW03	PSW	37.4	2070				61.7			317	4380 J
IWW Ditch Sediments	FSDIWW04	PSW	12.6	1570				45.6			185	1980 J
IWW Ditch Sediments	FSDIWW05	PSW	72.8	2910				58.6			460	8230 J
IWW Ditch Sediments	FSDIWW06	PSW	22.8	1840				39.4			276	2730 J
Railroad Swale Sediments	FSDRRS01	PSW	9.4	7140				68			1000	2770 J
Coke Settling Pond Sediments	FWSCSP01	PSW	0.72 U	565 J		764		0.1 UJ		3.11 U	7.1	67.4

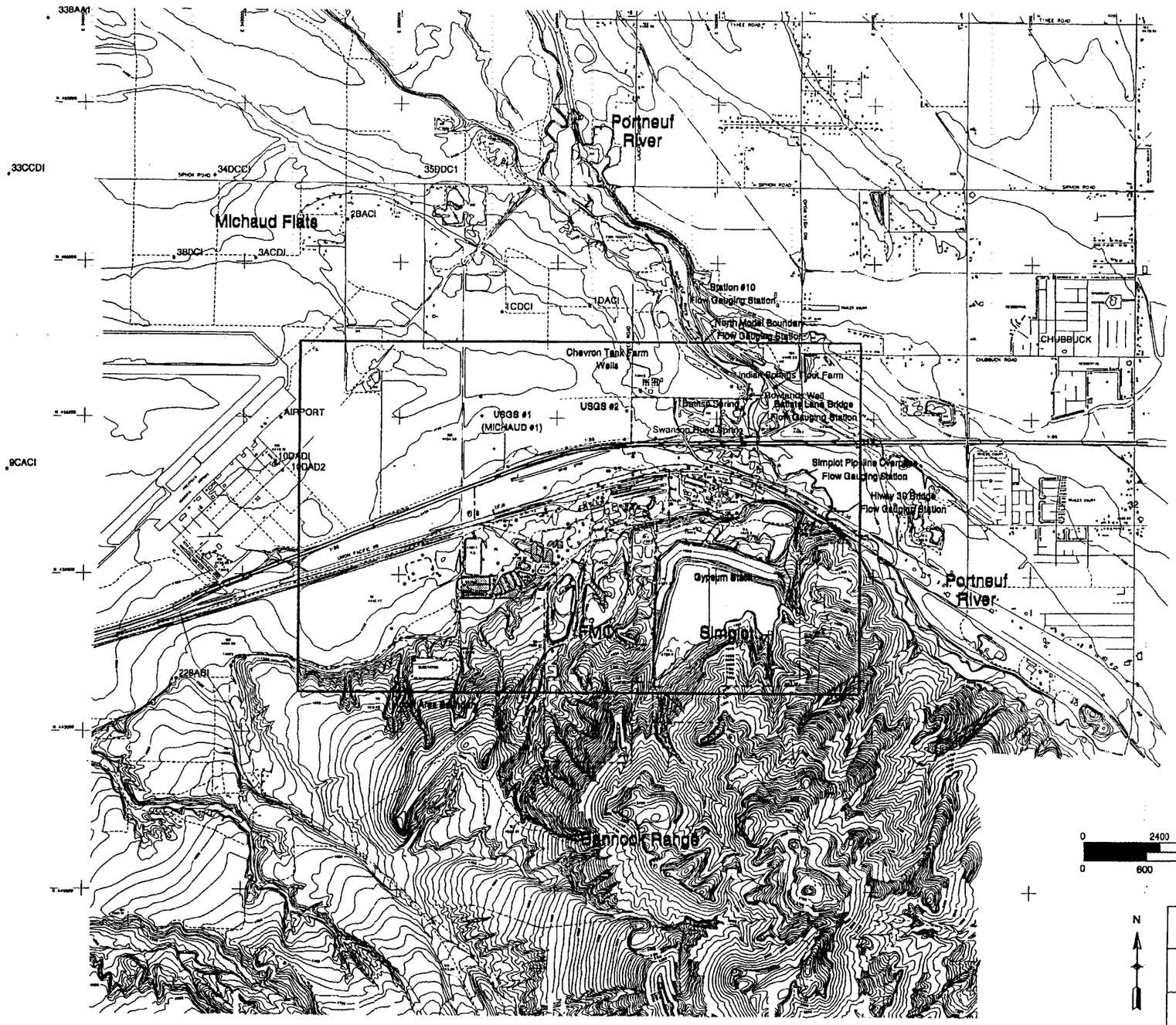
Notes:

*Results with sample type PSL are in mg/l and with PSW are in mg/kg.

**Results with sample type PSL are in pCi/l and with PSW are in pCi/g.

U = Not detected.

J = Estimated value.



Legend

35DDC1 • Boring and Well Locations
(See Figure 3.3-3 for Base Map & Well Designations Within Model Boundary)

Old Ponds (FMC)

Model Boundary

EMF Property Boundary

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EASTERN MICHAUD FLATS
POCATELLO, IDAHO

EMF Flow Model Study Area

Job Number	Drawing No.	Rev.
21372	FIGURE 3.3-2	

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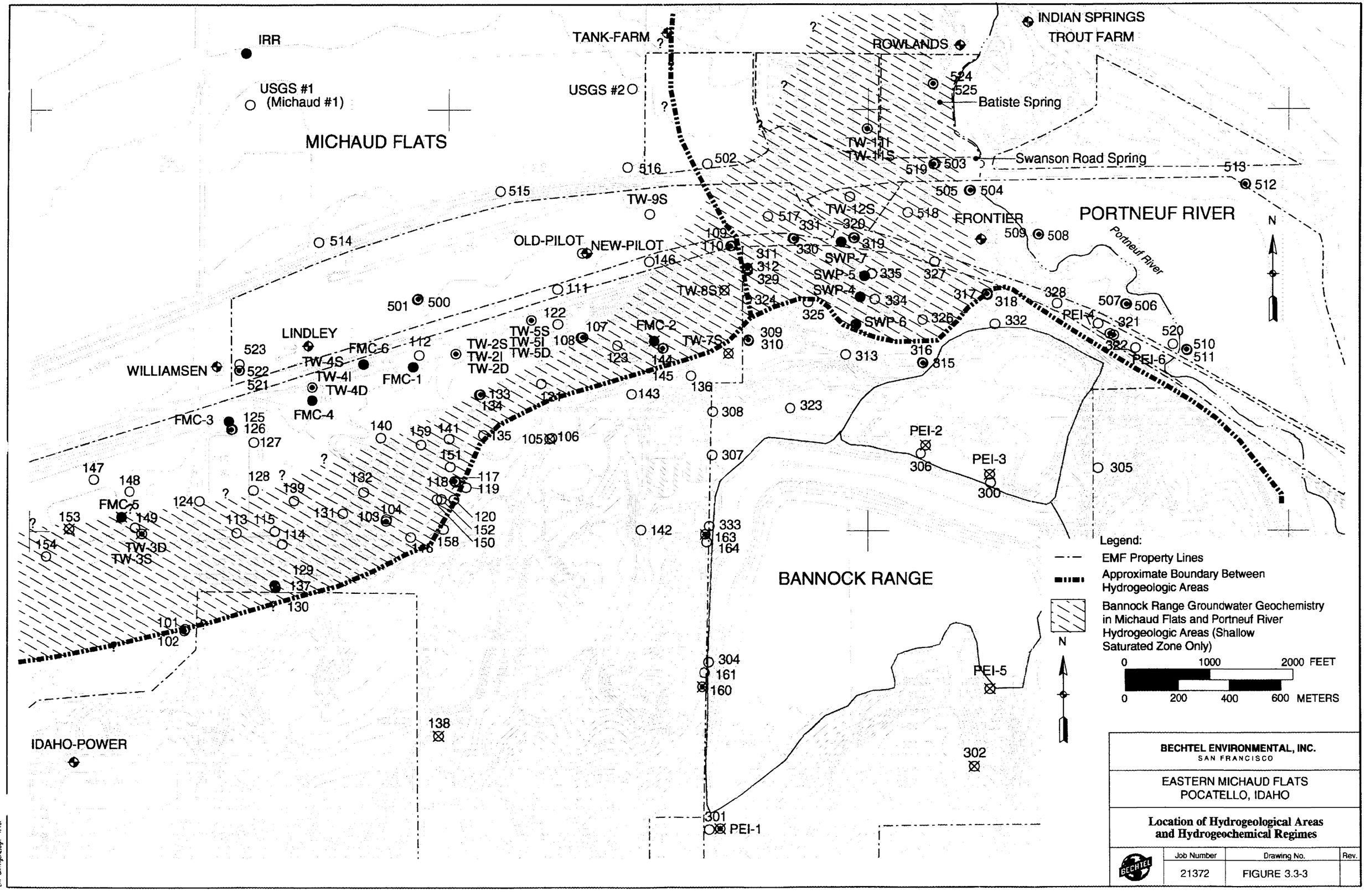

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Location of Hydrogeological Areas and Hydrogeochemical Regimes

Job Number	Drawing No.	Rev.
21372	FIGURE 3.3-3	

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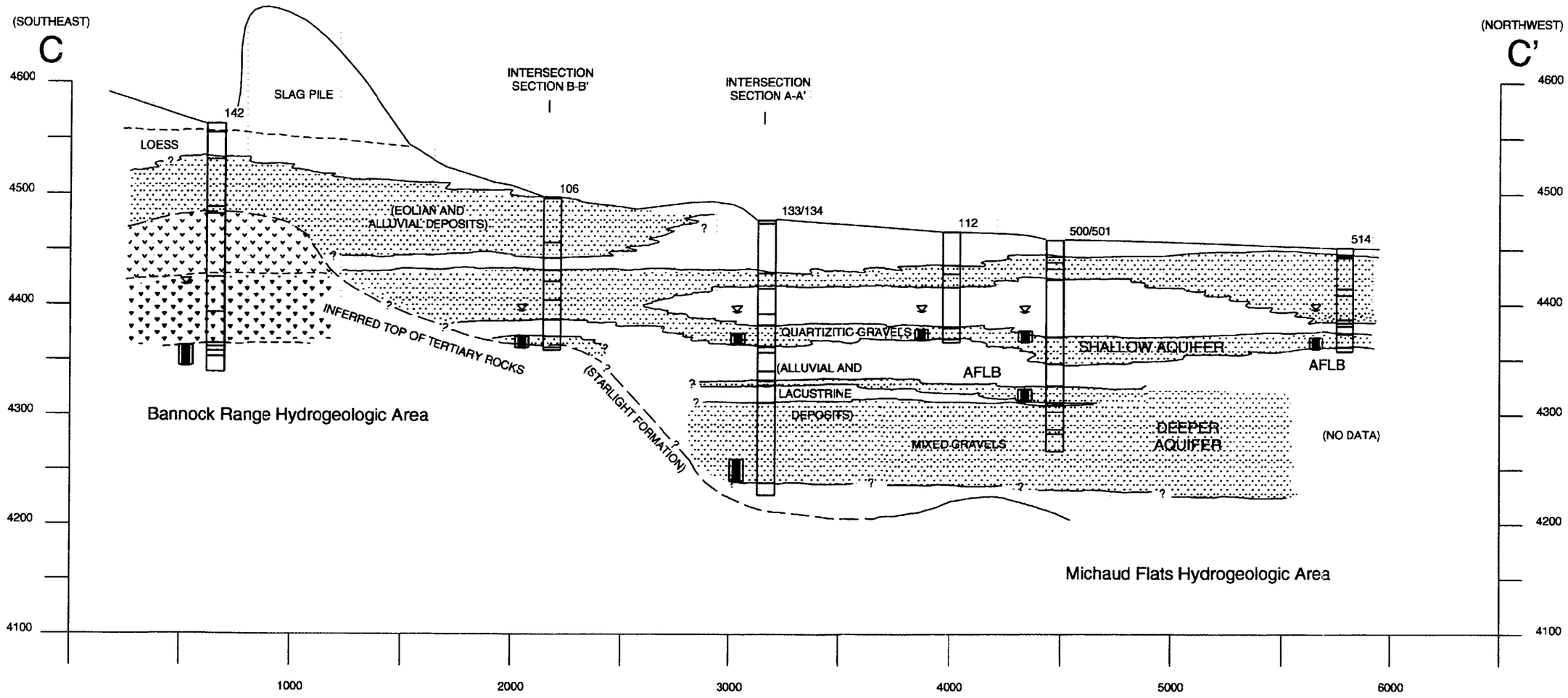

Notes:

1) Ground surface line generalized.
2) Vertical exaggeration = 5x
3) Cross-section is generalized. See boring logs in Appendix for further details.
4) Cross-section lines are shown in Figure 3.1-5.
5) AFLB = American Falls Lake Beds

Legend:

- Water level
- Well screen

SAND, GRAVELLY SAND, SILTY SAND, CLAYEY SAND, SANDSTONE, GRAVEL, SAND AND GRAVEL, SILTY, SANDY GRAVEL, SILTY GRAVEL, CLAYEY GRAVEL

SILT, CLAYEY SILT, SANDY SILT, GRAVELLY SILT

CLAY, SILTY CLAY, SANDY CLAY, GRAVELLY CLAY

BASALT, RHYOLITE, TUFF

CALICHE, PEAT

ASPHALT, CONCRETE, FILL

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POCATELLO, IDAHO

Hydrogeologic Cross-Section C-C'

Job Number	Drawing No.	Rev.
21372	FIGURE 3.3-4	

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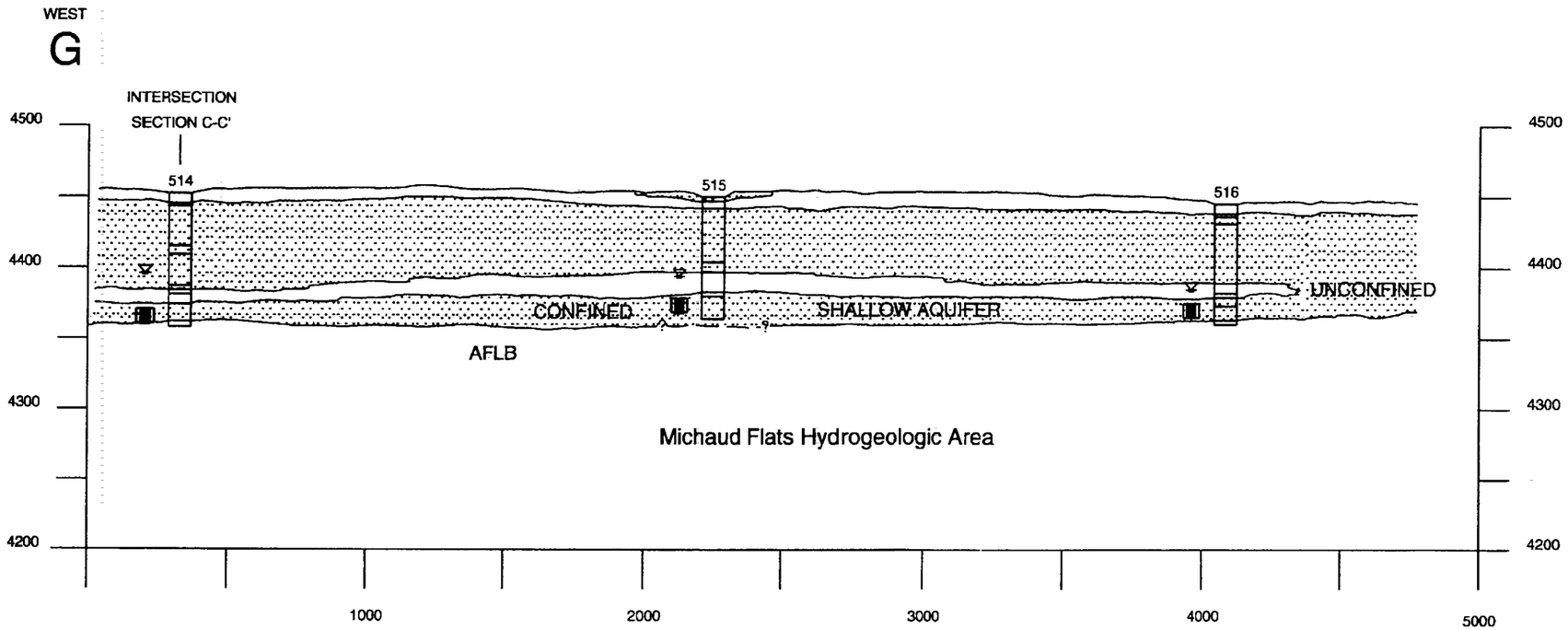
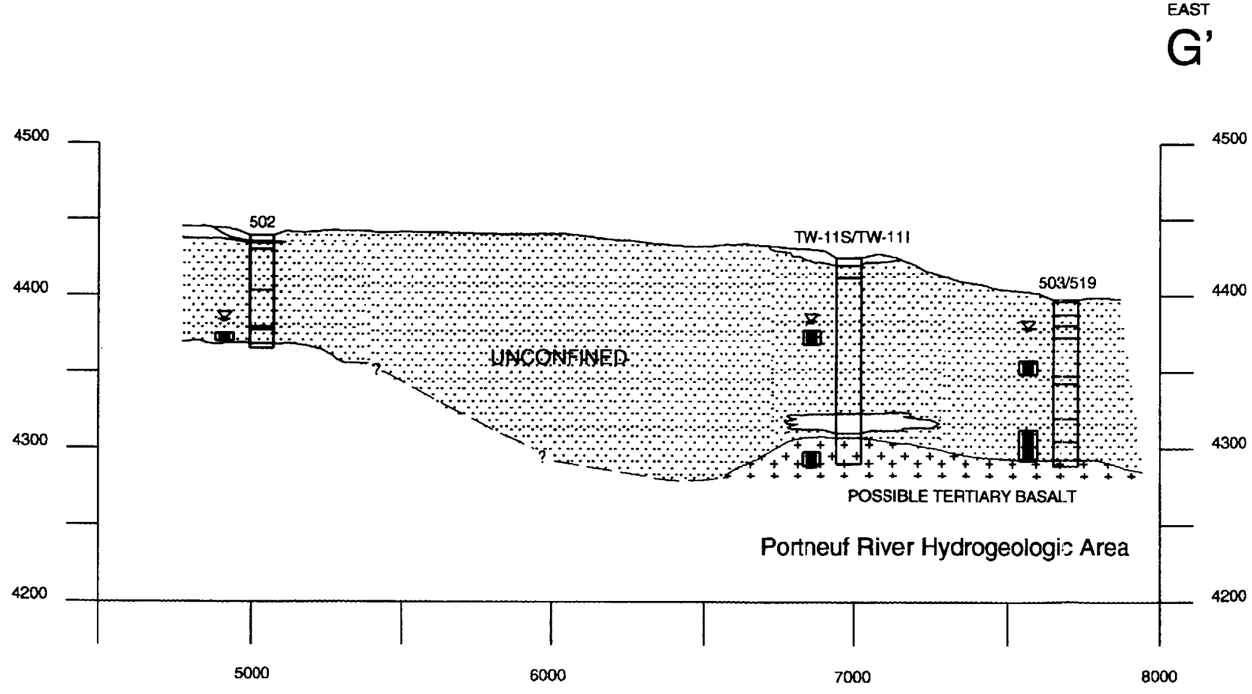


Notes:

1) Ground surface line is generalized.
2) Vertical exaggeration = 5x
3) Cross-section is generalized. See boring logs in Appendix for further details.
4) Cross-section lines are shown in Figure 3.1-5.
5) AFLB = American Falls Lake Beds

Legend:

- Water Level
- Well Screen



- SAND
- GRAVELLY SAND
- SILTY SAND
- CLAYEY SAND
- SANDSTONE
- GRAVEL
- SAND AND GRAVEL
- SILTY, SANDY GRAVEL
- SILTY GRAVEL
- CLAYEY GRAVEL
- SILT
- CLAYEY SILT
- SANDY SILT
- GRAVELLY SILT
- CLAY
- SILTY CLAY
- SANDY CLAY
- GRAVELLY CLAY
- BASALT
- RHYOLITE
- TUFF
- CALICHE
- PEAT
- ASPHALT
- CONCRETE
- FILL

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Hydrogeologic Cross-Section G-G'

Job Number	Drawing No.	Rev.
21372	FIGURE 3.3-5	

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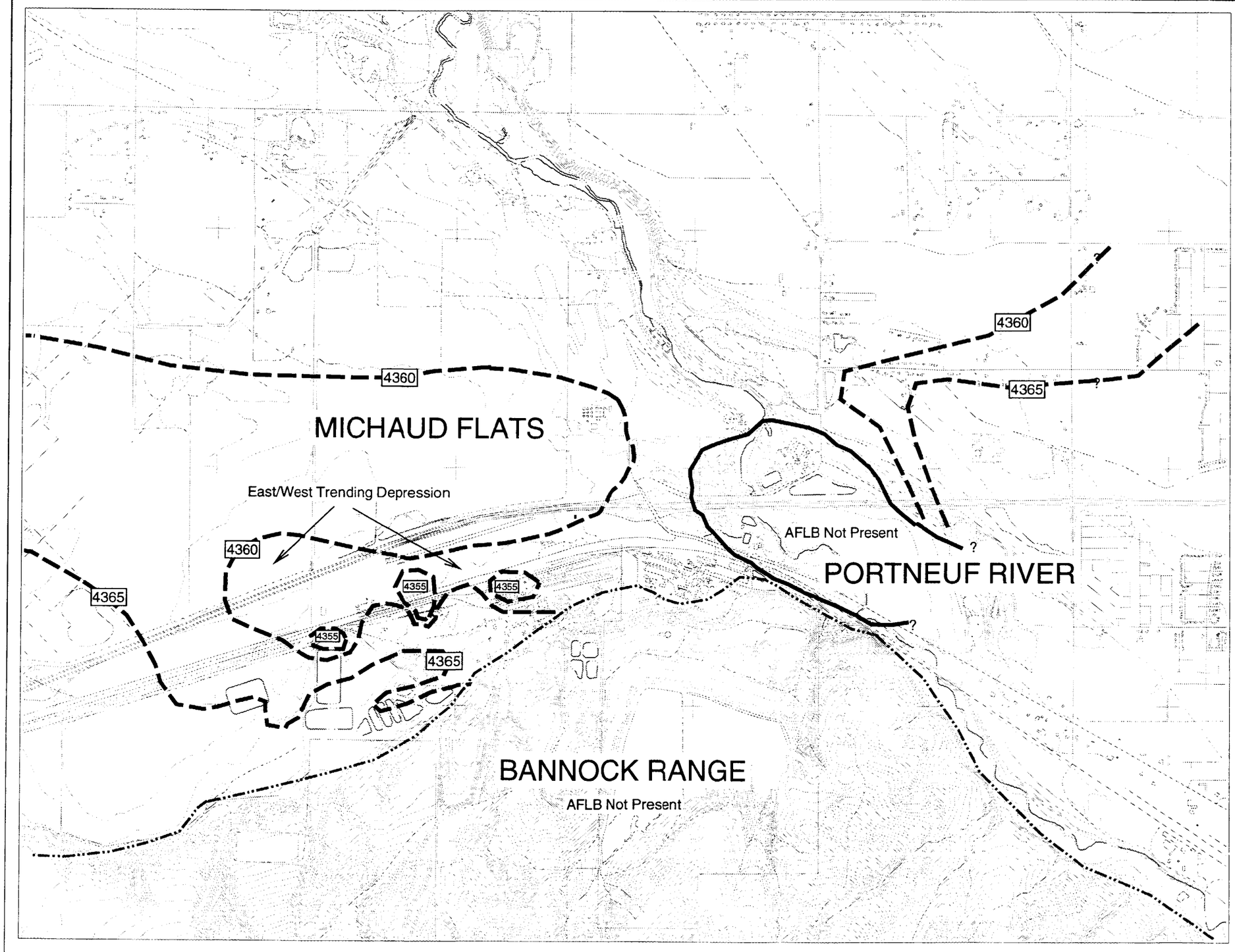


EXPLANATION

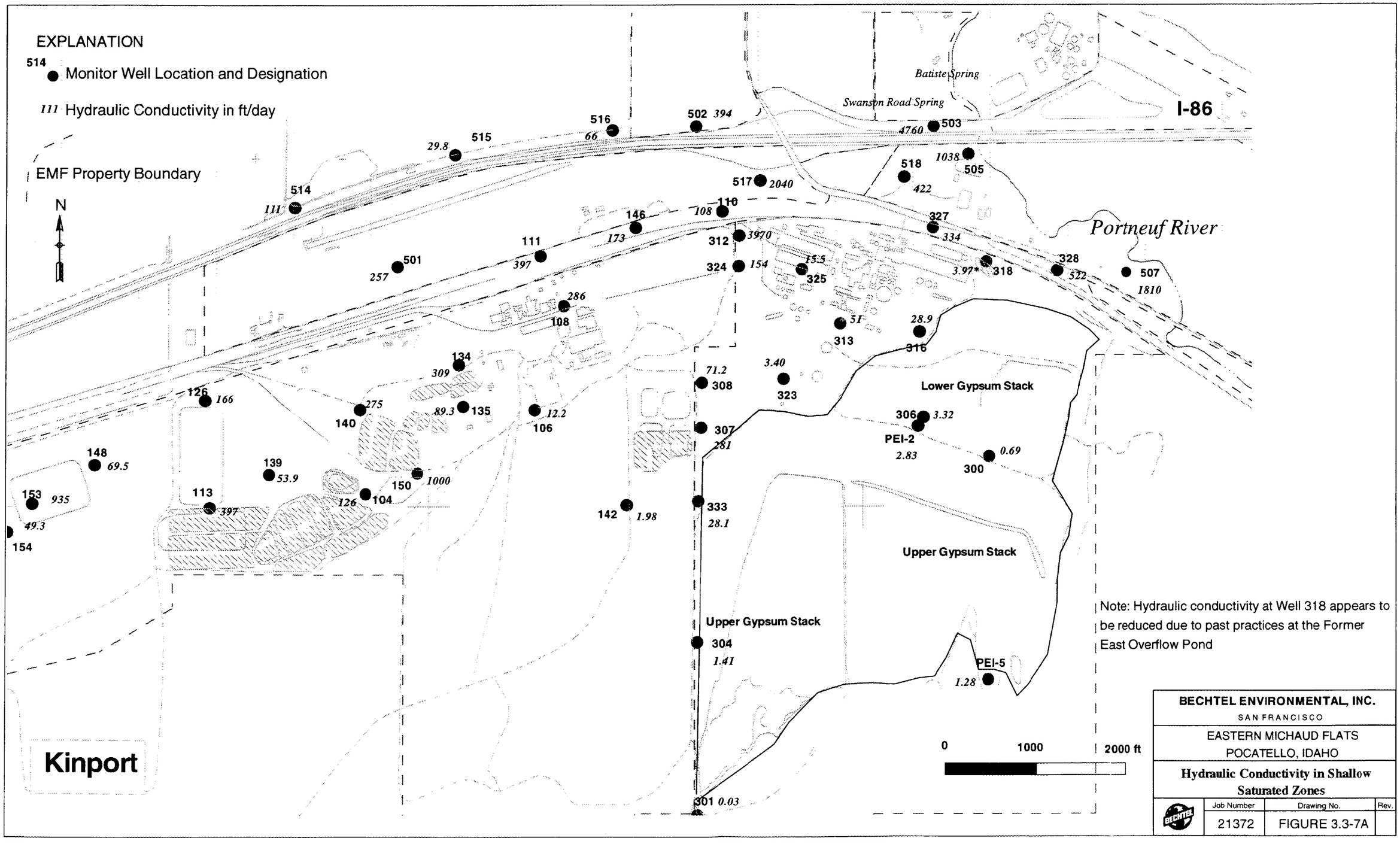
Elevation Contour on Top Surface of AFLB (in feet above msl)

4360

0 2500 5000 feet

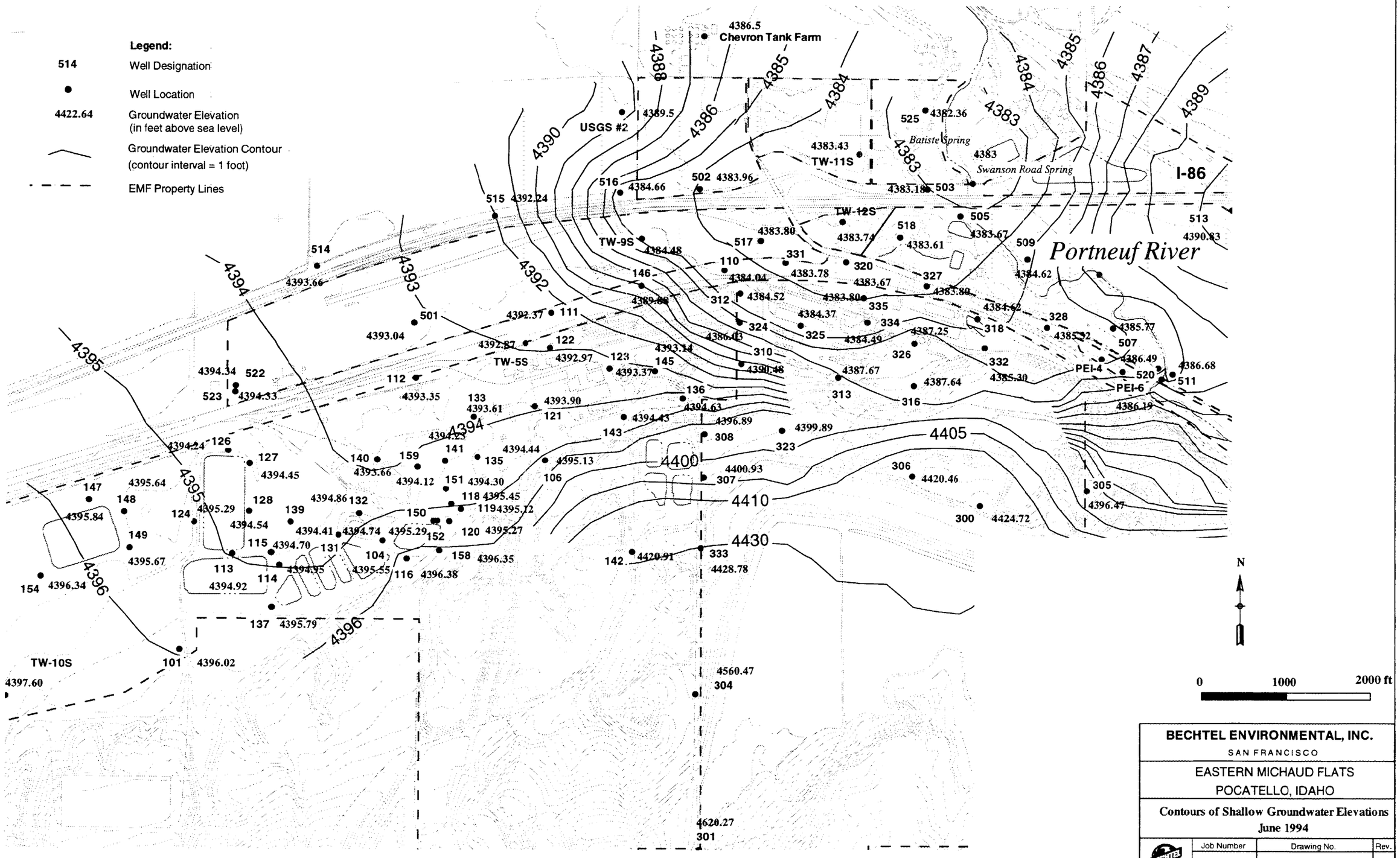
N

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
EASTERN MICHAUD FLATS POCATELLO, IDAHO		
Configuration of American Falls Lake Beds		
Job Number	Drawing No.	Rev.
21372	FIGURE 3.3-6	



Note: Hydraulic conductivity at Well 318 appears to be reduced due to past practices at the Former East Overflow Pond

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO			
EASTERN MICHAUD FLATS POCATELLO, IDAHO			
Hydraulic Conductivity in Shallow Saturated Zones			
	Job Number	Drawing No.	Rev.
	21372	FIGURE 3.3-7A	



BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Contours of Shallow Groundwater Elevations
June 1994

Job Number	Drawing No.	Rev.
21372	FIGURE 3.3-8F	

APPENDIX C
ESTIMATED INFILTRATION RATES FOR GROUNDWATER REMEDIAL ALTERNATIVES 2B and 3B

APPENDIX C - GROUNDWATER MODEL REPORT FOR THE FMC PLANT OPERABLE UNIT
Average Evaporation and Percolation for Groundwater Remedial Alternative 2B

Extraction Rate/Discharge Flow = 530 gpm 102,032 ft^3/day Percolation Rate= 5E-04 cm/sec 3E-01 in/day

Area Required= 3,594,718 ft^2 83 Acres

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual Total	Annual Flow
Average Precipitation (Inches)	0.94	1.00	1.11	1.10	0.95	1.11	1.22	1.29	0.97	0.60	0.65	0.82	11.76	50 gpm (avg)
Evaporation Rate (Inches)	2.61	0	0	0	0	1.19	2.02	3.3	4.92	7.13	6.98	4.47	32.62	140 gpm (avg)
Percolation Rate (Inch)	8.8E+00	8.5E+00	8.8E+00	8.8E+00	7.9E+00	8.8E+00	8.5E+00	8.8E+00	8.5E+00	8.8E+00	8.8E+00	8.5E+00	103.46	**440 gpm (avg)**
Net Water loss Rate (Inches)	10.46	7.50	7.68	7.69	6.99	8.86	9.30	10.80	12.45	15.32	15.12	12.15	124.32	530 gpm (avg)
Net Water Loss in the Ponds (ft^3)	3,132,651	2,247,846	2,300,884	2,303,065	2,094,525	2,655,569	2,785,882	3,233,948	3,730,863	4,588,870	4,527,981	3,639,627	37,241,711	
Water Applied (ft^3)	3,162,995	3,060,963	3,162,995	3,162,995	2,856,898	3,162,995	3,060,963	3,162,995	3,060,963	3,162,995	3,162,995	3,060,963	37,241,711	530 gpm (avg)
Water Volume in the Ponds (ft^3)	30,344	843,460	1,705,571	2,565,501	3,327,874	3,835,300	4,110,380	4,039,427	3,369,527	1,943,652	578,665	0		
Water Depth in the Pond (in)	0.10	2.82	5.69	8.56	11.11	12.80	13.72	13.48	11.25	6.49	1.93	0		

APPENDIX C - GROUNDWATER MODEL REPORT FOR THE FMC PLANT OPERABLE UNIT
Average Evaporation and Percolation for Groundwater Remedial Alternative 3B

Extraction Rate/Discharge Flow = 670 gpm 128,984 ft^3/day Percolation Rate= 5E-04 cm/sec 3E-01 in/day

Area Required= 4,544,267 ft^2 104 Acres

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual Total	Annual Flow
Average Precipitation (Inches)	0.94	1.00	1.11	1.10	0.95	1.11	1.22	1.29	0.97	0.60	0.65	0.82	11.76	60 gpm (avg)
Evaporation Rate (Inches)	2.61	0	0	0	0	1.19	2.02	3.3	4.92	7.13	6.98	4.47	32.62	180 gpm (avg)
Percolation Rate (Inch)	8.8E+00	8.5E+00	8.8E+00	8.8E+00	7.9E+00	8.8E+00	8.5E+00	8.8E+00	8.5E+00	8.8E+00	8.8E+00	8.5E+00	103.46	**560 gpm (avg)**
Net Water loss Rate (Inches)	10.46	7.50	7.68	7.69	6.99	8.86	9.30	10.80	12.45	15.32	15.12	12.15	124.32	670 gpm (avg)
Net Water Loss in the Ponds (ft^3)	3,960,143	2,841,617	2,908,664	2,911,422	2,647,796	3,357,040	3,521,775	4,088,198	4,716,374	5,801,024	5,724,052	4,601,038	47,079,144	
Water Applied (ft^3)	3,998,503	3,869,519	3,998,503	3,998,503	3,611,551	3,998,503	3,869,519	3,998,503	3,869,519	3,998,503	3,998,503	3,869,519	47,079,144	670 gpm (avg)
Water Volume in the Ponds (ft^3)	38,359	1,066,261	2,156,100	3,243,180	4,206,935	4,848,398	5,196,141	5,106,446	4,259,591	2,457,069	731,520	0		
Water Depth in the Pond (in)	0.10	2.82	5.69	8.56	11.11	12.80	13.72	13.48	11.25	6.49	1.93	0		

United States
Environmental Protection
Agency

EXPLANATION OF SIGNIFICANT DIFFERENCES FACT SHEET

STAUFFER CHEMICAL
SUPERFUND SITE
Tarpon Springs, Pinellas County, Florida
June 2007

Summary of Explanation of Significant Differences

EPA plans to substitute a groundwater "cut off" wall for the use of in-situ solidification (ISS) to reduce the potential for contaminant migration from the former waste ponds. EPA plans to make this change because of implementation issues identified during the pilot testing of the ISS technology. During this testing, a reaction occurred between elemental phosphorus and the cement slurry which contributed to a fire in the test area. In addition, there is debris in portions of the old ponds which makes solidification impracticable. Some of the debris likely contains residual elemental phosphorus.

The use of a cut off wall will reduce the movement of groundwater contamination. The wall would be installed below ground around the perimeter of the former waste ponds. Modifying this component of the remedy will avoid the problems associated with implementing ISS at full scale.

Other components of the remedy, including capping and restrictions regarding future on-site groundwater use and land use, remain unchanged. The capping called for in the ROD will cover contaminated soil including the area inside the subsurface cut off wall and will form a protective barrier designed to prevent contact with contaminated materials.

Introduction

This Explanation of Significant Differences (ESD) for the Stauffer Chemical (Stauffer) Site in Tarpon Springs, Pinellas County, Florida, has been prepared by the Region 4 Office of the United States Environmental Protection Agency (EPA). The purpose of this ESD is to change the solidification component of the Site remedy. Based on the experience from the pilot study for the in situ solidification (ISS) component of the selected remedy, EPA has decided to use a groundwater cut off wall instead of ISS.

This ESD is being issued as part of the public participation responsibilities under Section 117 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and Section 300.435(c)(2)(i) of the National Contingency Plan (NCP), 40 C.F.R. Part 300.

The Administrative Record contains documents used as the basis for the remedy selection at the Site, including the Pond Remedy Assessment Report and the Pond Remedy Conceptual Design. This ESD will become part of the Administrative Record in accordance with Section 300.825(a)(2) of the National Contingency Plan. The Administrative Record documents are available for public review and copying in the Stauffer Site information repository. The repository is located at the Tarpon Springs Library located at 138 East Lemon Street.

New Site Information Prompting ESD

The field experience gained from the pilot test provides the new information prompting this ESD. The pilot test for ISS was conducted during late January to mid February 2006. On February 15, 2006, a fire occurred in the test area. The fire resulted from a reaction between the elemental phosphorus below ground and the cement mixture used for solidification. This reaction contributed to the formation of phosphine gas which would bubble through the cement slurry, exposing elemental phosphorus to the air. The onsite workers used water, sand, and a carbon/sand mixture in efforts to control the fire. Ultimately, the Tarpon Springs Fire department responded to the incident. The Site workers continued to control flare ups on the test cell that evening and continued monitoring for several days.

During this event, phosphine was detected on site near the test cell and at the southern site boundary near the Anclote River. However, off-site air monitoring, which was conducted by the Tarpon Springs Fire Department, showed no presence of phosphine. In addition, ATSDR and the Florida Department of Health evaluated the air monitoring data and concluded that there would be no off-site health impacts as a result of the incident.

Metal debris was also noted in portions of the former waste ponds targeted for ISS. The debris interferes with the mixing operation required for ISS, further complicating the implementation of the ISS portion of the Site remedy. In addition, some of the debris likely contains elemental phosphorus, making it more difficult to excavate and safely handle the debris prior to performing solidification.

As a result of the pilot scale study, EPA has concluded that the ISS portion of the remedy should not be implemented at the full scale. There is a potential that a larger phosphorus fire could occur or a greater amount of phosphine could be generated during full scale operations if larger quantities of elemental phosphorus are encountered during the ISS operations.

Because of the identified implementation problems for ISS that are due to the presence of elemental phosphorus and metal debris, EPA has determined that it is necessary to change this component of the Record of Decision (ROD). This change consists of using a groundwater cut off wall instead of ISS to reduce potential contaminant migration from the pond material through the shallow groundwater.

The cut off wall would be constructed of interlocking sheetpile panels driven below the ground surface to a depth of approximately 10-20 feet. The cut off wall would be installed around the perimeter of the waste ponds. The cut off wall will channel horizontal groundwater flow around the contaminated pond sediments that are located below the water table, thus reducing potential contaminant migration.

According to previous groundwater studies conducted at the Site, there is not a strong vertical gradient between the surficial aquifer and the Upper Floridan aquifer. Also, the groundwater studies noted that groundwater contamination in the surficial aquifer is mainly found in or adjacent to source areas such as the former waste ponds.

The concept of the cut off wall is presented in this fact sheet. The exact configuration of the cut off wall will be further refined during the design process. The conceptual layout is noted in Figures 1 and 2. Figure 1 shows the entire site property and the location of the cut off wall. Figure 2 shows a more close up view of the location of the cut off wall. The wall is open at the western end because a completely enclosed layout could potentially increase the downward vertical movement of groundwater and contaminants to the Upper Floridan aquifer.

The next design document will be the preliminary remedial design which may be completed by the fall of 2007 and will be made available to the public. The preliminary design will include the subsurface cut off wall and the caps over contaminated soil/sediment including the area inside the subsurface cut off wall.

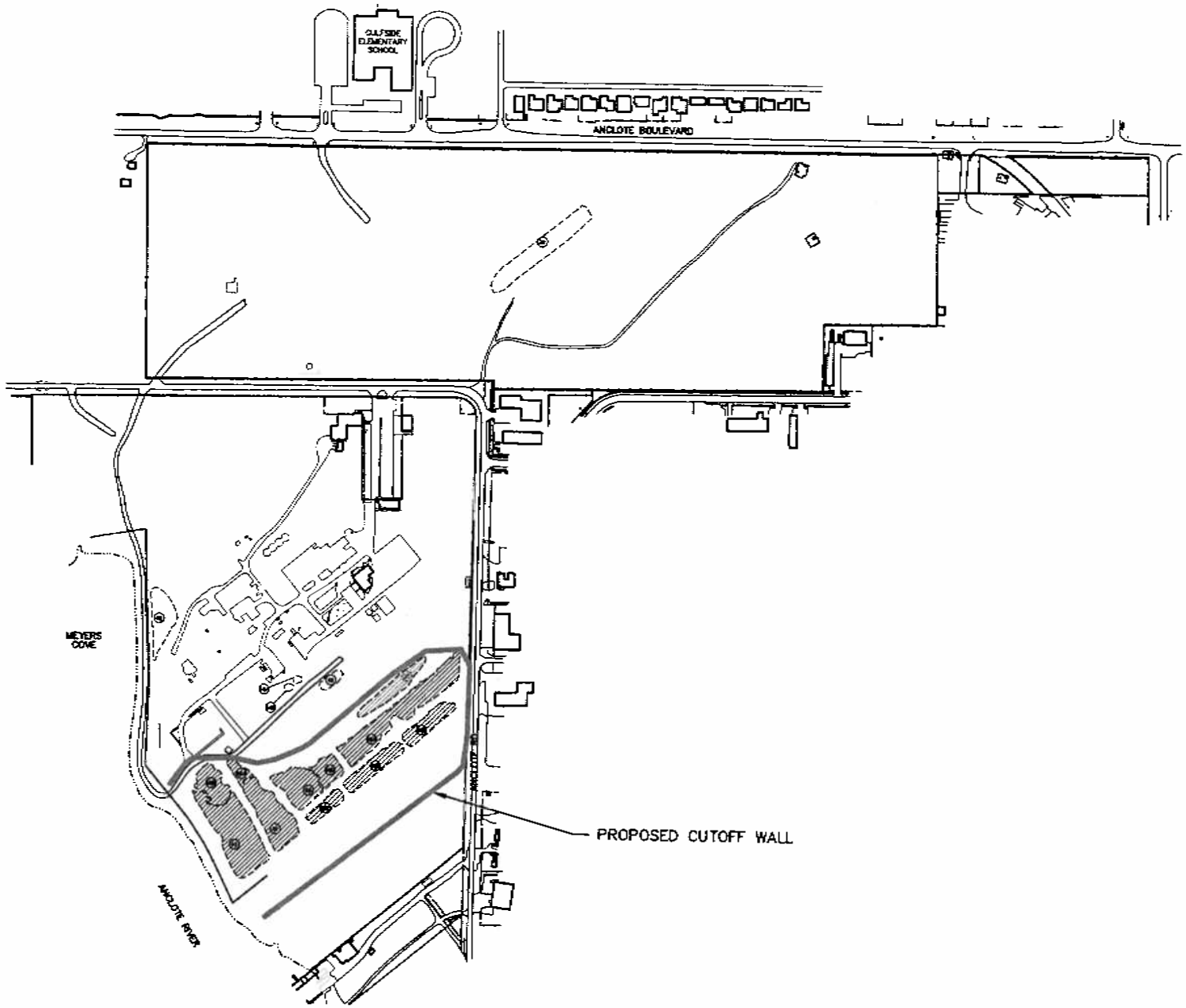


FIGURE 1

LEGEND

PROPOSED CUTOFF WALL LOCATION

POND NUMBER

STAUFFER CHEMICAL SUPERFUND SITE TARPON SPRINGS, FL

CUTOFF WALL CONCEPTUAL SITE LOCATION PLAN

NOT TO SCALE

FILE NO. 5618.33542

O'BRIEN & GERE

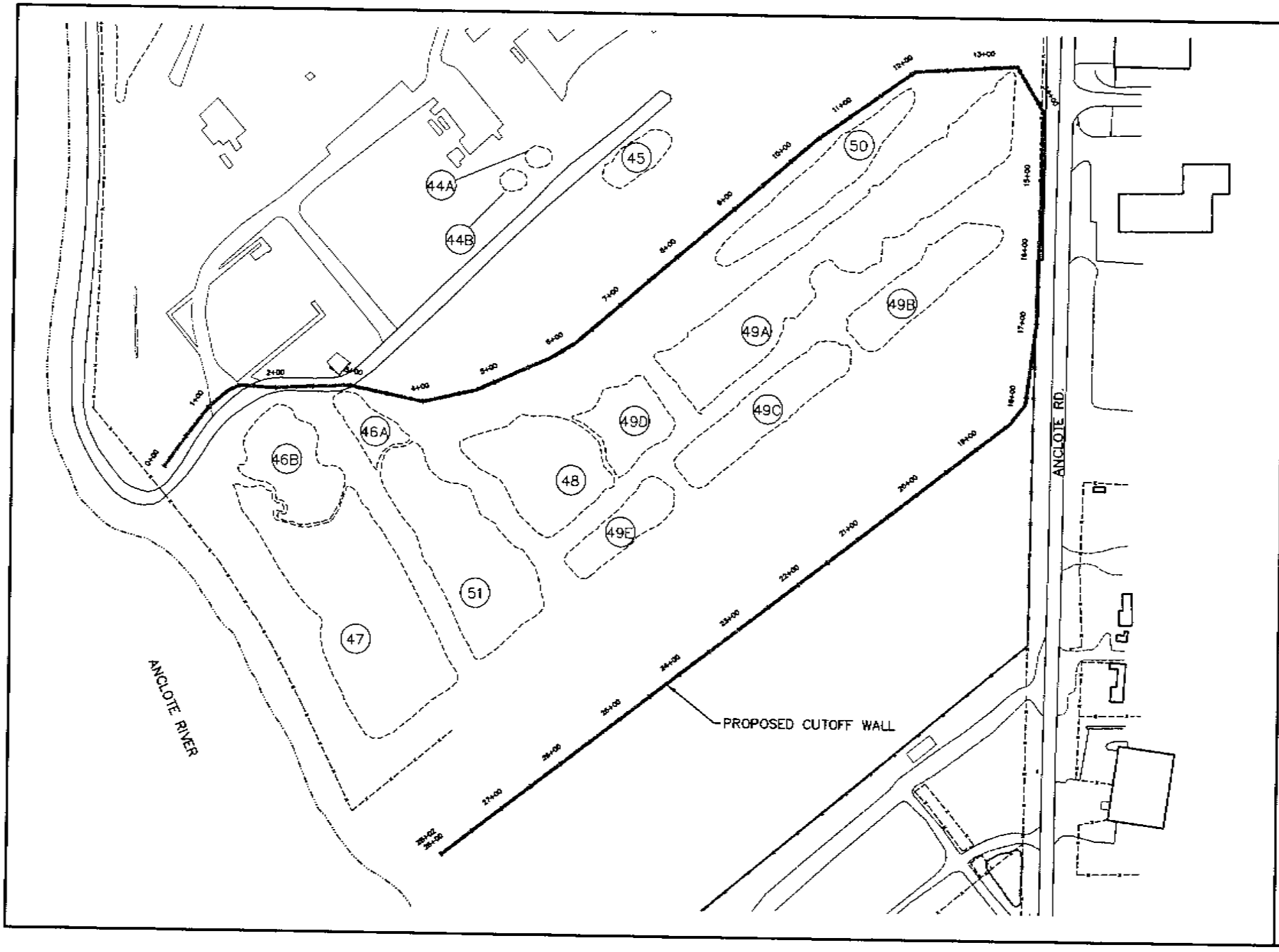


FIGURE 2

LEGEND

PROPOSED CUTOFF WALL LOCATION

POND NUMBER

STAUFFER CHEMICAL SUPERFUND SITE TARPON SPRINGS, FL.

CUTOFF WALL CONCEPTUAL LOCATION PLAN

NOT TO SCALE

FILE NO. 5618.33562

O'BRIEN & GERE

The NCP at 40 C.F.R. 300.435, notes that after adoption of a ROD, or the settlement or the entry of a Consent Decree, if the remedial or enforcement action taken differs from the remedy selected in the ROD with respect to scope, performance, or costs, the lead agency shall consult with the support agency, as appropriate and either publish an ESD or propose an amendment to the ROD. An ESD is required when the differences significantly change, but do not fundamentally alter the remedy. An example of a significant change is a change to a component of a remedy which does not fundamentally alter the overall cleanup approach. An ESD is the appropriate mechanism to document this significant change to one component of the Stauffer remedy. Through this ESD, the basic concept of managing the contaminated pond material in place is retained. It is expected to result in a minimal change in the overall cost of the Site remedy. In addition, the potential risk to future users of the Site is addressed by the capping component of the remedy. The capping called for in the ROD will cover contaminated soil including the area inside the subsurface cut off wall and will form a protective barrier designed to prevent contact with contaminated materials.

Site Background Information

The Stauffer Chemical Superfund Site is a former elemental phosphorus plant. The Site property is about 130 acres in size and is located on Anclote Road in Tarpon Springs, Pinellas County, Florida. The Site is near the Pinellas/Pasco County border, and lies along the Anclote River two miles upstream from the Gulf of Mexico. The Site property is generally flat with an average elevation of 10 feet above sea level. The City of Tarpon Springs is located approximately two miles southeast of the Site. Land use in the surrounding area includes light industrial, commercial and residential.

Operations at the Stauffer Site began in 1947 under the ownership of the Victor Chemical Company (Victor). The plant produced elemental phosphorus using phosphate ore. Stauffer purchased the plant from Victor in 1960 and operated it until it shut down operations in 1981. In 1983, the plant, including most process buildings, was decommissioned and dismantled. The only remaining structures at the Site are an old office building, former lunch room, guard building, and an equipment storage building. While operating, the plant used a system of seventeen unlined waste ponds on the Site. Site contaminants include arsenic, antimony, beryllium, elemental phosphorus, thallium, and radium-226.

EPA Actions at the Site

The Site was initially proposed for inclusion on the National Priorities List (NPL) in February 1992. Stauffer commenced a Remedial Investigation and Feasibility Study (RI/FS) for the Site pursuant to 40 C.F.R. §300.430 and in accordance with an administrative order on consent (AOC) issued by EPA. The Site was placed on the NPL on May 31, 1994. Stauffer completed a Remedial Investigation (RI) Report in December 1993 and completed a Feasibility Study (FS) Report in March 1996. This study evaluated the contamination at the Site, determined the potential risks posed by the contaminants, and identified and evaluated methods for remediating the contamination. On July 2, 1998, EPA issued a ROD for the Site.

After the ROD was signed, Stauffer entered into a RD/RA Consent Decree to perform the design and construction of the remedy. Based upon public comments received on the first Consent Decree that was lodged in April 2000, the first Consent Decree was withdrawn. Stauffer Management Company then entered into an agreement with EPA to conduct additional Site characterization studies. The studies were designed to address specific questions about sink holes, other features of the Site, and the selected remedy, to further ensure that the selected remedy was safe and would provide long term protection of human health and the environment over the life of the remedy. All of the studies have been completed and included separate geophysical, groundwater, and treatability studies reports which were approved by EPA on May 20, 2004. The findings of these studies support the selected remedy outlined in the ROD and provide a further technical basis for the remedial design. These

studies did not recommend changing any of the remedial requirements contained in the ROD. Upon completion of these additional studies, EPA and Stauffer Management Company negotiated another RD/RA Consent Decree. On October 20, 2005, the RD/RA Consent Decree was entered by the U.S. District Court for the Middle District of Florida.

Original Record of Decision

On July 2, 1998, EPA issued a ROD for Operable Unit #1 (OU#1) at the Site. The ROD addressed the first of two operable units planned for the Site. OU#1 addressed the source areas – contaminated soils and sediments.

The major components of the original selected soils remedy included:

•limited excavation of radiologically and chemically contaminated material/soil exceeding cleanup standards
•consolidation of contaminated material/soil in the main pond area, slag area, and/or other areas on-Site
•placement of caps over the consolidation areas; the caps will meet requirements of Florida Administrative Code § 62-701.600.
•Placing institutional controls on the Site, including deed restrictions, land use ordinances, physical barriers, and water supply well permitting restrictions
•in-situ solidification/solidification of pond material and contaminated soil below the water table in the consolidation areas on-Site. **This component of the remedy is the subject of this ESD. A cut-off wall will be used instead of in-situ solidification for the former waste ponds** (the capping called for in the ROD will cover contaminated soil including the area inside the subsurface cut off wall and will form a protective barrier designed to prevent contact with contaminated materials).

Statutory Determination

The selected remedy as modified by this ESD for the Stauffer Chemical Company Superfund Site OU#1 ROD remains protective of human health and the environment, complies with CERCLA, the NCP and state requirements that are applicable or relevant and appropriate to the remedial action and is cost-effective. FDEP, as the support agency, agrees with this ESD.

Next Steps

EPA will also hold a public availability session to discuss this ESD. In addition, Stauffer will proceed with the preliminary design of the overall Site remedy, including capping and the cut off wall. The preliminary design may be completed by the fall of 2007 and will be made available to the public.

Public Availability Session
June 12, 2007
6:00-8:00 pm
Tarpon Springs Public Library
138 East Lemon Street
Tarpon Springs, FL 34689
727/943-4922

Supporting documentation for this ESD can be found in the Administrative Record which is stored locally at the Tarpon Springs Public Library as noted above.

AUTHORIZING SIGNATURE:

Franklin Hill, Acting Division Director
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U.S. Environmental Protection Agency
Region 4

Date: 5/24/07

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Atlanta, GA 30303
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Mon-Fri (8:30am - 4:30pm)

INTERIM CERCLA GROUNDWATER MONITORING PLAN

FMC PLANT OPERABLE UNIT

Prepared for:

FMC Idaho, LLC
P.O. Box 4111
Pocatello, ID 83202

JULY 2010

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INTERIM CERCLA GROUNDWATER MONITORING PLAN

1.0 INTRODUCTION

1.1 BACKGROUND

The FMC plant is included within the Eastern Michaud Flats (EMF) Superfund site, which was placed on the National Priorities List (NPL) on August 30, 1990. FMC has been conducting CERCLA groundwater monitoring in conjunction with its ongoing RCRA groundwater monitoring program and Calciner Pond Remedial Action groundwater monitoring program. The RCRA groundwater monitoring program began in 1991 at essentially the same time as the EMF site CERCLA Preliminary Site Characterization Study (PSCS) and Remedial Investigation (RI) groundwater investigations and monitoring. The Calciner Pond Remedial Action groundwater monitoring commenced during the second quarter of 2003 under the IDEQ-FMC voluntary consent order (VCO) for remedial action at the calciner ponds. FMC has been conducting its CERCLA groundwater monitoring program voluntarily since the EMF Site ROD was issued in 1998. Due to the fact that a Remedial Design / Remedial Action (RD/RA) Consent Decree to implement the FMC Plant OU groundwater remedy, including the long-term groundwater monitoring specified in the 1998 ROD, was never entered, an EPA-approved CECLA groundwater monitoring plan has not been required nor prepared.

Following permanent shut-down of the FMC plant in December 2001, EPA and FMC entered into an AOC for a Supplemental Remedial Investigation and Feasibility Study SRI/SFS) at the FMC Plant Operable Unit (OU). Although the AOC and Statement of Work (SOW) for the FMC SRI/SFS did not require a supplemental groundwater investigation(s) at the FMC Plant OU, FMC recognizes the need to address groundwater (both EMF impacts identified during the EMF RI and the potential for future impacts) during the SFS for the FMC Plant OU. FMC prepared a Groundwater Current Conditions Report (GWCCR) for the FMC Plant OU (FMC, June 2009) as a compendium of the extensive EMF RI and post-RI groundwater investigations, results and evaluations to support the SFS for the FMC Plant OU. One of EPA's comments on the draft GWCCR was "FMC's voluntary CERCLA ground water monitoring program must make a transition as soon as possible into an interim ground water monitoring program that must be approved by EPA with the development of site specific DQO's. This interim program will continue until an amended ROD has been signed for FMC. Then a long-term ground water monitoring program will be developed once a remedy is selected." (EPA, February 2009).

During a series of EPA-FMC meetings during February, March and May 2009, FMC and EPA began moving forward toward development of both an interim and long-term CERCLA groundwater monitoring program for the FMC Plant OU. FMC recently finalized the Groundwater Current Conditions Report (GWCCR) for the FMC Plant OU (FMC, June 2009) and EPA approved the GWCCR by letter dated July 20, 2009. Consistent with EPA's direction, this interim CERCLA Groundwater Monitoring Plan is being submitted as an appendix to the SFS Report for the FMC Plant OU.

1.2 GROUNDWATER MONITORING OBJECTIVES

The objective of the interim CERCLA groundwater monitoring program is to collect sufficient data of known quality to, in conjunction with the RCRA and Calciner Pond remedial action groundwater monitoring programs, evaluate potential changes and/or trends in site-related groundwater constituents and evaluate groundwater conditions on an OU-wide basis.

Although the 1998 ROD selected source controls for the old phossy ponds area, calciner sediment storage area and the railroad swale, no Remedial Design and Remedial Action Consent Decree (RD/RA CD) was entered to implement those remedies. Therefore, those CERCLA remedial actions have not been implemented as of 2010. The SFS for the FMC Plant OU is evaluating various soil and groundwater remedial alternatives that include source control actions and long-term monitoring. At such time that EPA selects the soil and groundwater remedies for the FMC Plant OU in a ROD amendment and makes those remedies implementable through a RD/RA Consent Decree, a long-term groundwater monitoring plan will be prepared that will include evaluation of the effectiveness of the CERCLA source control actions and groundwater remedy.

1.3 PLAN ORGANIZATION

Section 2 presents a summary of the current RCRA, Calciner Pond Remedial Action and voluntary CERCLA groundwater monitoring programs and the current groundwater quality at the FMC Plant OU. Section 3 presents a summary of the monitoring plan components. Section 4 describes the data evaluation methods and procedures. Reporting procedures are described in Section 5. The Field Sampling Plan is presented in Attachment A and the Quality Assurance Project Plan is presented in Attachment B. The Data Verification and Data Validation Protocol is presented in Attachment C.

2.0 SUMMARY OF FMC GROUNDWATER MONITORING PROGRAMS

The EMF remedial investigation/feasibility study (RI/FS) that included substantial hydrogeologic and groundwater quality and transport investigations was initiated in 1992, and was completed at the EMF site in 1996 (Bechtel, 1996). The EMF Site ROD was issued in 1998 and FMC has been conducting its voluntary CERCLA groundwater monitoring program since that time.

Following permanent shut-down of the FMC plant in December 2001, EPA and FMC entered into an AOC for a Supplemental Remedial Investigation and Feasibility Study SRI/SFS) at the FMC Plant OU. Although the AOC and Statement of Work (SOW) for the FMC SRI/SFS did not require a supplemental groundwater investigation(s) at the FMC Plant OU, FMC recognizes the need to address groundwater (both EMF impacts identified during the EMF RI and the potential for future impacts) during the SFS for the FMC Plant OU.

In 2008, FMC assembled the substantial post-RI groundwater information developed under multiple regulatory programs and agencies into a single compendium for the purpose of the Administrative Record for the FMC Plant OU. The Groundwater Current Conditions Report for the FMC Plant Operable Unit ("GWCCR," MWH, 2009) provides a summary of the extensive groundwater investigations undertaken during the Eastern Michaud Flats (EMF) Remedial Investigation (RI) [Bechtel, 1996] and presents a comprehensive update of the groundwater studies and monitoring performed at the FMC Plant OU subsequent to the EMF RI up through FMC's May 2008 groundwater monitoring event. The groundwater monitoring program summaries presented below are described in greater detail in the GWCCR.

2.1 SUMMARY OF RCRA AND CALCINER POND GROUNDWATER MONITORING PROGRAMS

2.1.1 RCRA Groundwater Monitoring

In 1991, FMC began RCRA groundwater monitoring of the Waste Management Units (WMUs) that FMC listed on its March 1991 Part B permit application for the FMC Pocatello facility. At that time, there were six WMUs subject to the RCRA quarterly groundwater monitoring requirements. FMC's RCRA groundwater monitoring analytical parameter list was consistent with the CERCLA inorganic and radiological parameter list (34 inorganic and 4 radiological parameters).

In parallel with FMC's and Simplot's request to reduce the CERCLA groundwater monitoring program, FMC in 1995 also requested a reduction in its RCRA groundwater monitoring program. In a letter dated June 13, 1995, EPA agreed with FMC's request to reduce the RCRA groundwater monitoring. Specifically, the RCRA analytical parameter list was reduced from 34 inorganic and 4 radiological parameters to 10 inorganic parameters, including cadmium that was retained at EPA's request. The RCRA groundwater monitoring well network was also modified in 1995, 1997 and 1998 as described in Section 3.2.1.1 of the GWCCR.

During EPA's review of the Pond 8S and Slag Pit Sump Closure Plans and associated Groundwater Monitoring Plans, EPA requested and FMC agreed to add two additional inorganic parameters to the groundwater monitoring for those WMUs: total phosphorus (quarterly) and elemental phosphorus (semi-annually).

As a result of the EPA-approved reduction in parameters, well network modifications, and addition of total phosphorus and elemental phosphorus to the Pond 8S and Slag Pit Sump groundwater monitoring plans, FMC's current RCRA groundwater monitoring program consists of the following:

- Quarterly groundwater monitoring;
- Field parameters: water level (groundwater elevation), pH, specific conductance (SC), temperature and turbidity;
- Laboratory parameters: arsenic, cadmium, selenium, potassium, chloride, fluoride, ammonia, nitrate, orthophosphate, and sulfate. In addition, at the Pond 8S and Slag Pit Sump, total phosphorus is analyzed quarterly and elemental phosphorus (P4) is analyzed semi-annually; and,
- The RCRA groundwater monitoring well network consists of 33 wells and Batiste Spring (surface water station) as listed on Table 2-1 and shown on Figure 2-1.

The RCRA groundwater monitoring is currently being conducted during the post-closure period per the RCRA Groundwater Monitoring Plans for each of the monitored RCRA WMUs (FMC, 1999). The RCRA groundwater monitoring plans are incorporated in and a part of the EPA-approved post-closure plans for these WMUs. For example, the Post-Closure Plan for Pond 18 Cell A includes the RCRA Sampling and Analysis Plans for Post-Closure Monitoring at RCRA Pond 18 Cell A. The RCRA Sampling and Analysis Plan (SAP) for post-closure groundwater monitoring consist of the Quality Assurance Project Plan (QAPjP) (Attachment 10-1 of the Pond 18 Cell A Post-Closure SAP) and the Field Sampling Plan (FSP) for RCRA Groundwater Monitoring (Attachment 10-2a of the Pond 18 Cell A Post-Closure SAP). Other than the monitoring well network associated with each WMU, the post-closure groundwater monitoring SAPs (QAPjP and FSP) are substantively the same for each of the WMUs suject to RCRA groundwater monitoring requirements. FMC reports the results of the RCRA groundwater monitoring for each of the WMUs subject to the groundwater monitoring requirements to EPA annually (calendar year basis) in the RCRA Annual Groundwater Monitoring Assessment Reports.

2.1.2 Calciner Pond Remedial Action Groundwater Monitoring

Pursuant to the Consent Order between the Idaho Department of Environmental Quality (IDEQ) and FMC for remediation of the calciner ponds, FMC submitted a Calciner Pond Remedial Action Groundwater Monitoring Plan to IDEQ. The Calciner Pond Remedial Action Groundwater Monitoring Plan (FMC, November 2008) was approved by IDEQ by letter dated

December 3, 2008. As described in the Monitoring Plan, monitoring wells upgradient and downgradient of the calciner ponds are sampled on a routine basis to evaluate the effectiveness of the remedial action in preventing the release of constituents from the calciner ponds to groundwater. The groundwater monitoring program commenced during the second quarter of 2003 with scheduled sampling of then existing wells 142, 161, 164, 136 and 143. New wells 189 and 190 were installed, developed and sampling began during the third quarter of 2003. The Calciner Pond Groundwater Monitoring Plan network of wells is listed on Table 2-1 and shown on Figure 2-1.

The Calciner Pond Remedial Action Groundwater Monitoring Plan is consistent with the reduced, focused EMF RI CERCLA groundwater monitoring program, as follows:

- Semi-annual groundwater monitoring;
- Field parameters: water level (groundwater elevation), pH, specific conductance (SC), temperature and turbidity;
- Laboratory parameters: arsenic, selenium, potassium, chloride, fluoride, ammonia, nitrate, total phosphorus (orthophosphate until 2008), and sulfate; and,
- Upgradient wells 142, 161, and 164; and downgradient wells 136, 143, 189 and 190 as listed on Table 2-1 and shown on Figure 2-1.

Calciner ponds groundwater monitoring was performed during implementation of the Calciner Pond Remedial Action (2003 through 2005) and is currently continuing during the post-remedial monitoring and maintenance period per the IDEQ Consent Order. FMC reports the results of the calciner ponds groundwater monitoring annually (calendar year reporting period) to IDEQ in a Calciner Pond Remedial Action Groundwater Monitoring Annual Report.

2.2 SUMMARY OF FMC'S VOLUNTARY CERCLA MONITORING PROGRAM

As described in Section 3.1.1 of the GWCCR, the reduced, focused EMF RI CERCLA groundwater monitoring program was implemented in 1994. FMC continued the reduced, focused EMF RI groundwater monitoring until EPA issued the ROD for the EMF Site in 1998. Upon issuance of the ROD, the requirement for EMF RI groundwater monitoring expired pursuant to the terms of the 1991 AOC for the EMF RI/FS.

After the 1998 ROD, FMC voluntarily continued monitoring of the CERCLA groundwater well network primarily to preserve spatial and temporal continuity of the groundwater database in anticipation of a Remedial Design and Remedial Action (RD/RA) Consent Decree for the FMC Plant OU. At that time, the FMC CERCLA groundwater monitoring program remained consistent with the reduced EMF RI CERCLA groundwater monitoring as follows:

- Semi-annual groundwater monitoring;

- Field parameters: water level (groundwater elevation), pH, specific conductance (SC), temperature and turbidity;

- Laboratory parameters: arsenic, selenium, potassium, chloride, fluoride, ammonia, nitrate, orthophosphate and/or total phosphorus, and sulfate; and,

- Twenty-three site-wide wells: 101, 110, 111, 134, 136, 139, 140, 142, 143, 146, 151, 159, 161, 164, 502, 515, 523, 524, 525, Old Pilot, TW-9S, TW-11S and TW-12S as listed on Table 2-1 and shown on Figure 2-1.

A RD/RA Consent Decree to implement the FMC Plant OU groundwater remedy was never entered. FMC has continued the semi-annual groundwater monitoring frequency and the same field and analytical parameters as specified in the 1998 ROD, and periodically made adjustments to better focus the network of wells that were routinely monitored. This interim CERCLA groundwater monitoring plan was developed to formalize the CERCLA groundwater monitoring program until such time that EPA issues a ROD amendment for the FMC Plant OU and a RD/RA Consent Decree is entered to implement the soil and groundwater remedies. FMC expects that a long-term groundwater monitoring plan will be a component of the EPA selected remedy and that plan will be developed as part of the RD/RA.

2.3 SUMMARY OF GROUNDWATER QUALITY CONDITONS THROUGH 2008

The GWCCR (MWH, 2009) provides a summary of the extensive groundwater investigations undertaken during the Eastern Michaud Flats (EMF) Remedial Investigation (RI) [Bechtel, 1996] and presents a comprehensive update of the groundwater studies and monitoring performed at the FMC Plant OU subsequent to the EMF RI up through FMC's May 2008 groundwater monitoring event. The monitoring wells associated with this monitoring program have been sampled at a quarterly to semi-annual frequency over a period of up to 17 years. A summary of the groundwater quality, primarily based on average results from 2006 to 2008, at the interim CERCLA program wells is presented in Table 2-2.

2.3.1 Groundwater Quality and Trends

The current (2009) spatial extent of the FMC-related groundwater impacts is comparable to that defined during the EMF RI (1993-1994). Concentrations of FMC-related groundwater impacts in the western ponds area, central plant area and downgradient portions of the joint fenceline / calciner ponds area have decreased (groundwater quality beneath the FMC Plant Site has improved) and are expected to continue to improve due to the lack of sustained hydraulic head on any identified or potential source areas at the site.

Increasing trends of sulfate, orthophosphate, potassium and arsenic in wells upgradient of the calciner ponds area (identified in the GWCCR as Remediation Unit [RU] 14) indicate that the Simplot gypstack is contributing increasing levels of these constituents to groundwater upgradient of RU 14 over time. There is consequently a potential for these constituents to

increase in concentration over time and potentially reverse the currently stable or decreasing concentration trends in the downgradient portions of the joint fenceline / calciner ponds area.

2.3.2 Source Area Evaluation

The following are the primary FMC-related source areas and source-distinguishable constituents contributing to groundwater impacts at the FMC Plant Site:

- Pond 8S within RU 22a (RCRA Ponds) - Potassium, chloride, sulfate, ammonia, nitrate, total phosphorus / orthophosphate, fluoride, arsenic, manganese, boron, selenium and total cyanide.

- Old "Phossy" Ponds (RU 22b) and portions of RU 13 with identified "phossy" pond solids in fill materials - Potassium, chloride, sulfate, ammonia, nitrate, total phosphorus / orthophosphate, fluoride, arsenic, manganese, boron, selenium and total cyanide.

- Furnace Building, Phos Dock and Secondary Condenser (RU 1) and Slag Pit (RU 2) – Elemental phosphorus.

- Former Kiln Scrubber Ponds and Calciners (RU 8) and Former Kiln Scrubber Overflow Pond (RU 9) - Ammonia, nitrate, fluoride, selenium, vanadium and total cyanide.

- Former Unlined Calciner Ponds, Calciner Sediment Storage Area 'A', Calciner Ponds (RU 14) - Potassium, chloride, fluoride, arsenic, manganese, boron and selenium.

- Calciner Solids Storage Area (RU 16) – Potassium, chloride, sulfate and selenium.

- Slag Pile (RU 19) – Potassium and sulfate.

Due to the migration of site-impacted groundwater from the western ponds area through the central plant area and multiple sources in the joint fenceline / calciner ponds area including the Simplot gypstack, the evaluation of groundwater constituents attributable to the source areas listed above focuses on the contaminants that can be distinguished from other sources—based on their higher concentrations compared to upgradient groundwater, or based on the fact that the constituents are unique in groundwater at that source area.

Because the IWW pond and ditch (RU 10) and the Railroad Swale (RU 22c) had a sustained hydraulic head, liquid from these areas likely migrated to groundwater to some extent. These areas thus may have been past sources of constituents to groundwater. However, there is currently no discernable contribution to site-impacted groundwater from these areas.

Based on the collective EMF RI and SRI investigations and post-RI groundwater monitoring, there is no evidence that the other RUs (or portions of those RUs not identified as source areas) are sources of groundwater impacts at the FMC Plant OU.

2.3.3 Groundwater Fate and Transport

The major groundwater flow characteristics of the EMF study area that includes the FMC and Simplot plant sites, as shown by the potentiometric contours and inferred flowpaths on Figure 2-2, can be summarized as follows:

- Northward flow from the western and central portions of the FMC Plant Site is limited to the area south of I-86 by converging flow of groundwater from the west and northwest.

- Groundwater from the western and central portions of the FMC Plant Site is swept eastward, south of I-86, and joins groundwater from the joint fenceline / calciner ponds area and from the Simplot plant.

- In the joint fenceline / calciner ponds area, groundwater from the western part of the Simplot gypsum stack flows in a northwesterly sweeping arc across the Simplot property boundary, flows beneath FMC property, where it commingles with flows from the eastern portions of FMC, and exits from the plant boundaries to the northeast near well 110.

- EMF facility-impacted groundwater migrates from the EMF facilities and discharges to the Portneuf River as bank seeps / springs and baseflow to the river at Swanson Road Spring (aka the Spring at Batiste Road), Batiste Spring, and the reach bounded by these two springs.

The most significant factor in the reduction of groundwater constituent concentrations is advective mixing. Mixing of small volumes of EMF-affected groundwater with large volumes of unaffected groundwater within the EMF aquifer system substantially reduces the concentration of all constituents, including conservative, non-attenuating solutes such as sulfate, along the groundwater flowpath.

2.3.4 Summary

The interim CERCLA groundwater monitoring program, in conjunction with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs, provides appropriate spatial and temporal coverage of the FMC Plant OU. As described in greater detail in Section 3, the interim CERCLA groundwater monitoring field and analytical parameters are appropriately focused on key parameters that define the extent of FMC-impacted groundwater and are consistent with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs. The groundwater monitoring results obtained under these monitoring programs will be used to evaluate any changes and/or trends in groundwater conditions as described in Section 4. In addition to the FMC groundwater monitoring program data, the Simplot groundwater monitoring data will be reviewed as part of the overall assessment of FMC Plant OU-wide groundwater quality and any trends, primarily in the joint fenceline area and in the area downgradient from both FMC's and Simplot's plant sites where Simplot has proposed to install additional monitoring wells.

TABLE 2-1. FMC'S ROUTINE GROUNDWATER MONITORING PROGRAM WELL NETWORKS (4Q 2010)

Area	Well Numbers	Up / Downgradient	Program [1]
Pond 18 Cell A	174	U	RCRA
	154, 177, 178	D	RCRA
Pond 17	173	U	RCRA
	171, 172, 180	D	RCRA
Pond 16S	154	U	RCRA
	147,148, 149	D	RCRA
Pond 15S	165	U	RCRA
	113, 115, 166	D	RCRA
Phase IV ponds	167	U	RCRA
	104, 114, 131, 168	D	RCRA
Pond 9E	124, 113	U	RCRA
	126, 127, 128	D	RCRA
Pond 8E	167	U	RCRA
	104, 114, 131, 168	D	RCRA
Pond 8S	158, 183	U	RCRA
	155, 156, 157	D	RCRA
Slag Pit Sump	121	U	RCRA
	108, 122, 123	D	RCRA
Batiste Spring	Batiste Spring	D	RCRA
Calciner Ponds	164, 161, 142	U	IDEQ
	136, 143, 189, 190	D	IDEQ
On-Plant Site	134, 139, 151, 159, 145	D	CERCLA
Downgradient from Plant Site	111, 146, 110, TW-9S	D	CERCLA
Downgradient from FMC and Simplot Plant Sites	517, TW-12S	D	CERCLA
Northern Perimeter of EMF Groundwater Impact [2]	523, 515, 502, TW-11S, 524, 525	Cross	CERCLA

Note: This table only includes the monitoring well networks for sampling and analysis. The list of wells designated for water level monitoring is presented in Section 3.1 of the ICGMP.
[1] Program: RCRA = RCRA groundwater monitoring plans, IDEQ = Calciner Pond groundwater monitoring plan, CERCLA = Interim CERCLA groundwater monitoring plan.
[2] Impact is in reference to detection of arsenic, nitrate or selenium above representative levels.

TABLE 2-2. SUMMARY OF GROUNDWATER QUALITY AT THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM WELLS

Parameters	**134**	**139**	**145**	**151**	**159**	**110**	**111**	**146**	**523**
Field Measurements									
pH (Field)	6.73	6.92	5.44	7.1	6.87	6.86	7.1	7.11	7.38
SC (UMHOS/CM)	2805	4643	5600	1250	2180	1429	1513	1294	893
Turbidity (NTU)	1.2	0.45	4.5	0.5	0.9	0.4	0.5	0.35	0.2
Water Temperature (°C)	16.9	12.8	15.3	16.3	16.8	17.1	14.8	16.9	13.4
General WQP (mg/L)									
Potassium	153	38.5	37.7	57.4	36.9	25.4	49.5	46.3	8.49
Sulfate	325	1051	2400	177	166	215	157	128	59.6
Chloride	287	886	154	114	210	89.8	170	132	108
Fluoride	0.2	0.583	0.5	NA	NA	0.435	0.105	0.378	0.5
Ammonia	0.5	0.175	2.5	<0.2	1.9	0.15	0.15	0.15	0.2
Nitrate	21.2	35.5	4.5	0.41	<0.1	3.8	8.98	6.13	4.5
Orthophosphate/ Total P	19.80	0.74	57.3	7.6	14.1	3.09	3.95	1.33	0.30
Metals (mg/L)									
Arsenic	0.098	0.039	0.298	0.031	0.093	0.048	0.024	0.029	0.004
Selenium	0.05	0.038	0.061	<0.005	<0.005	0.029	0.005	0.003	0.003

NA means parameter not analyzed.

Results are average for four sampling events (4Q06 to 2Q08) except the results for well 145 are from May 2008 and 151 and 159 are from November 2001 due to the lack of sufficient data points to calculate a current average value for these wells.

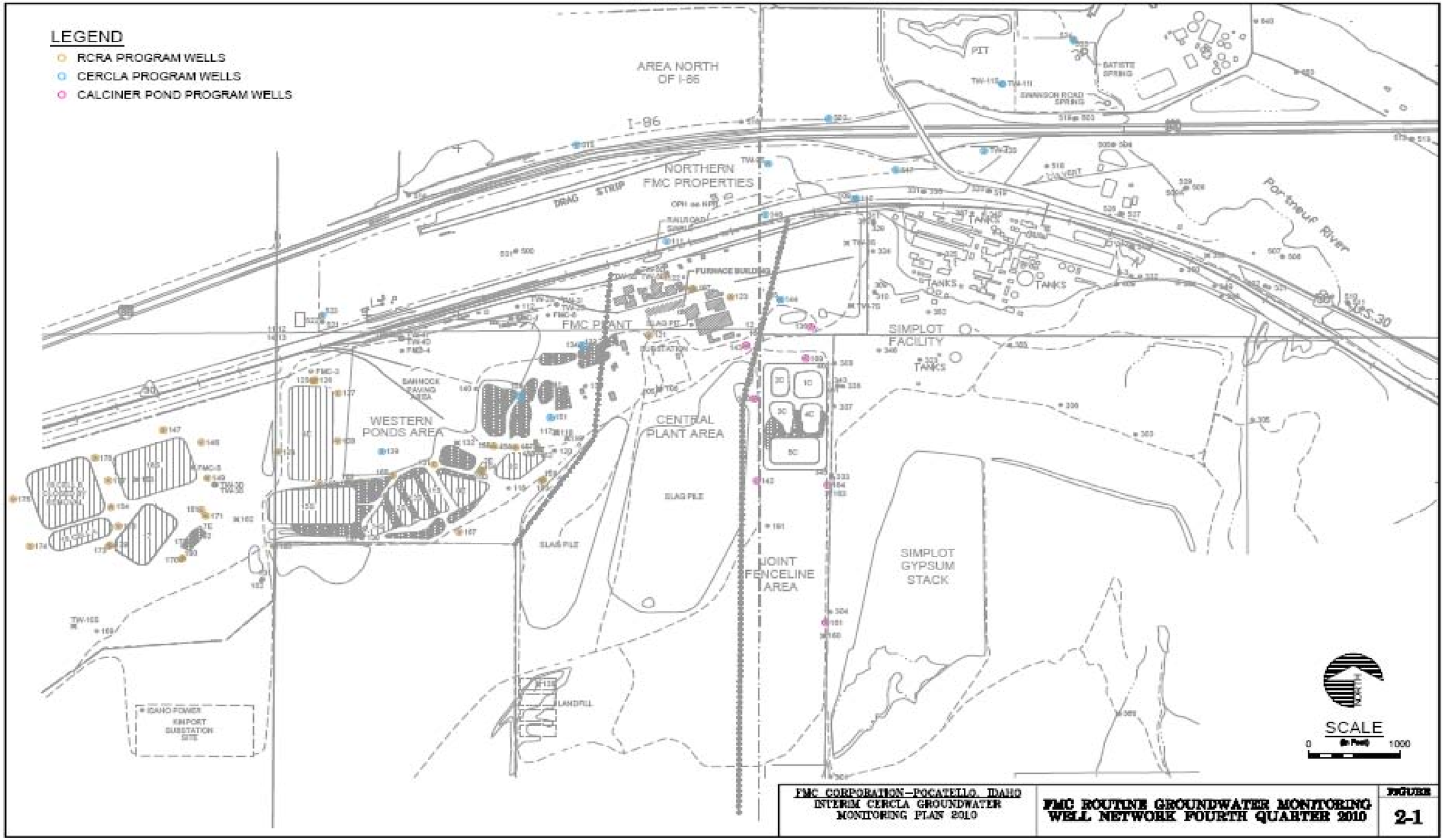
Non-detect results were included as equal to the detection limit for calculation of averages.

TABLE 2-2 (CONTINUED). SUMMARY OF GROUNDWATER QUALITY AT THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM WELLS

Parameters	**TW-9S**	**502**	**517**	**TW-12S**	**515**	**TW-11S**	**524**	**525**
Field Measurements								
pH (Field)	7.06	7.28	6.93	6.5	7.37	7.18	7.55	7.52
SC (UMHOS/CM)	1842	1036	2575	1125	1260	845	517	524
Turbidity (NTU)	8	0.2	0.3	8.5	0.475	9.5	0.325	0.35
Water Temperature (°C)	14.4	12.6	15.9	14.4	13.3	12.4	12.4	12.1
General WQP (mg/L)								
Potassium	58.4	5.4	100	15.7	8.85	3.8	4.21	4.15
Sulfate	161	64.9	189	132	132	49.7	42.9	44.6
Chloride	187	44.3	198	46.2	197	19.9	18.5	19.2
Fluoride	0.1	0.9	0.6	1.1	0.683	0.8	0.675	0.718
Ammonia	0.2	>0.2	0.2	0.7	0.15	<0.2	0.15	0.133
Nitrate	9.95	1.6	11.1	6.1	2.75	1.6	1.88	1.95
Orthophosphate/ Total P	3.21	<0.5	0.92	16.90	0.20	<0.5	0.20	0.25
Metals (mg/L)								
Arsenic	0.027	0.003	0.047	0.017	0.005	0.002	0.004	0.006
Selenium	0.005	>0.005	0.014	0.006	0.003	<0.005	0.005	0.005

Results are average for four sampling events (4Q06 to 2Q08) except for wells 502, 517 and TW-11S that are results for May 2008 only due to the lack of sufficient data points to calculate a current average value for these wells.

Non-detect results were included as equal to the detection limit for calculation of averages.


LEGEND
RCRA PROGRAM WELLS
CERCLA PROGRAM WELLS
CALCINER POND PROGRAM WELLS
AREA NORTH OF I-86
I-86
NORTHERN FMC PROPERTIES
DRAG STRIP
PIT
BATISTE SPRING
SWANSON ROAD SPRING
CULVERT
Portneuf River
TANKS
FURNACE BUILDING
FMC PLANT
SIMPLOT FACILITY
U.S. 30
WESTERN PONDS AREA
CENTRAL PLANT AREA
SLAG PILE
JOINT FENCELINE AREA
SIMPLOT GYPSUM STACK
LANDFILL
IDAHO POWER
EXPORT SUBSTATION SITE
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0
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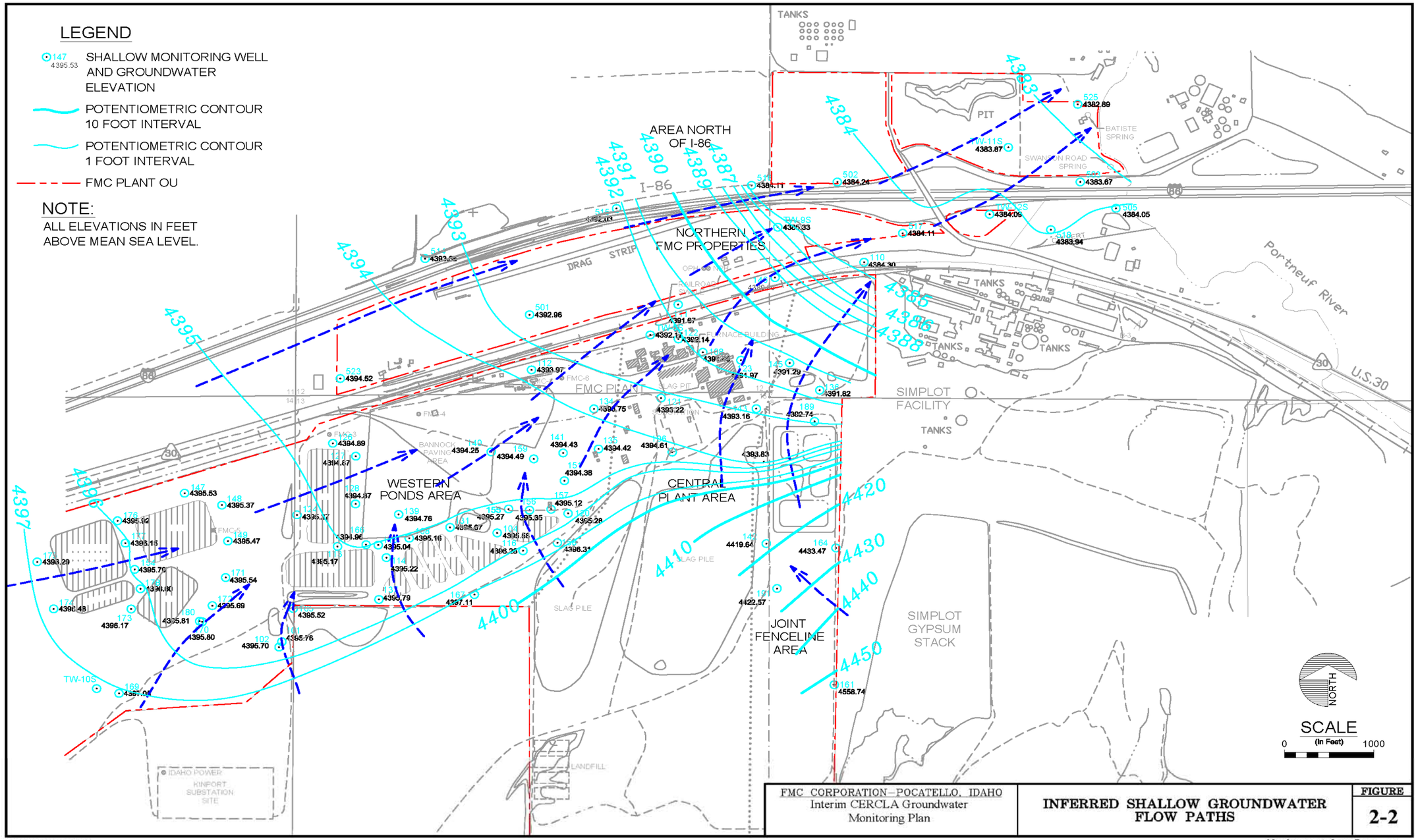
FMC CORPORATION–POCATELLO, IDAHO
INTERIM CERCLA GROUNDWATER MONITORING PLAN 2010
FMC ROUTINE GROUNDWATER MONITORING WELL NETWORK FOURTH QUARTER 2010
FIGURE
2-1



FMC CORPORATION–POCATELLO, IDAHO
Interim CERCLA Groundwater Monitoring Plan

INFERRED SHALLOW GROUNDWATER FLOW PATHS

FIGURE 2-2

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Hydrometrics, Inc.
Consulting Scientists and Engineers

3.0 SUMMARY OF MONITORING PLAN COMPONENTS

The interim CERCLA groundwater monitoring program is designed to provide adequate and appropriate data to address the groundwater monitoring objectives. This monitoring program was developed following the approach described in EPA's *Guidance for Monitoring at Hazardous Waste Sites: Framework for Monitoring Plan Development and Implementation* (EPA, 2004). The data acquisition activities are described in this section and the Field Sampling Plan ("FSP,"Attachment A) and the Quality Assurance Project Plan ("QAPP," Attachment B). The data evaluation methods and procedures are described in Section 4.

3.1 WATER LEVEL MONITORING

FMC performs quarterly groundwater level (elevation) measurements at numerous monitoring wells that provide uniform coverage across the entire FMC Plant OU. The results of the site-wide water level monitoring have been and will be collected and utilized under FMC's CERCLA, RCRA and Calciner Pond groundwater monitoring programs. During each groundwater monitoring event, water level measurements will be taken in accordance with the Field Sampling Plan at the following list of wells:

- Wells 101 through 191 inclusive consisting of 73 shallow and deep wells within the FMC "100-series" wells;
- TW-5S, TW-5I, TW-5D, TW-9S, TW-11S and TW-12S; and,
- 501, 502, 503, 505, 514, 515, 516, 517, 518, 523, 524 and 525.

In addition to the 91 wells listed above, the surface water elevation will be measured in the Batiste Spring channel immediately below the overflow weir from the springhouse cistern and in the Swanson Road Spring (aka the Spring at Batiste Road) basin.

3.2 INTERIM CERCLA MONITORING WELL NETWORK

Groundwater monitoring will be conducted in accordance with the FSP (Attachment A) and QAPP (Attachment B) presented in this document. Field parameters will be measured and samples for laboratory analyses will be collected at the following groundwater monitoring wells during each semiannual monitoring event:

- On-Plant Site wells: 134, 139, 151, 159 and 145 (in the joint fenceline area)
- Plant Site downgradient wells: 111, 146, 110 and TW-9S
- Wells downgradient from the FMC and Simplot Plant sites: 517 and TW-12S
- Northern perimeter wells: 523, 515, 502, TW-11S, 524 and 525

Because the three groundwater monitoring programs (CERCLA, RCRA and Calciner Pond) are coordinated, the CERCLA groundwater monitoring well network is shown along with the RCRA and Calciner Pond groundwater monitoring well networks that are sampled for field and laboratory analyses in Table 2-1 and on Figure 2-1.

During the series of EPA-FMC meetings (February, March and May 2009) that led to agreement for the development of this interim monitoring plan, EPA also expressed its position that a new groundwater monitoring well is needed on the FMC Plant Site in the joint fenceline area and in the vicinity of abandoned well TW-8S (refer to Figure 2-1). Based on further EPA-FMC discussions, EPA's objective for the new well would be to refine the extent of the Simplot gypstack influence in the joint fenceline area toward the northern FMC Plant Site boundary. Further discussion between EPA and FMC will be necessary to detail the specific objective, location, well installation and construction techniques prior to installation of the well. Therefore, a separate work plan will be prepared that will describe location, installation / construction, development, and initial monitoring / sampling of the new groundwater monitoring well (tentatively designated well 192). Following installation and initial sampling of the new monitoring well, the well will be added to the interim CERCLA monitoring well network described in this section and the FSP and QAPP.

3.3 FIELD PARAMETERS

Groundwater monitoring will be conducted in accordance with the FSP and QAPP presented in this document. The following field parameters will be measured in the monitoring wells during each semiannual monitoring event:

- Dissolved oxygen,
- Oxidation-reduction potential (ORP),
- pH,
- Turbidity,
- Temperature, and
- Specific conductance.

3.4 LABORATORY ANALYTICAL PARAMETERS

As described in detail in the GWCCR, the original EMF Remedial Investigation (RI) groundwater investigation analytical parameter list included a lengthy list of general minerals, nutrients and fluoride, metals and radionuclides. Based on the EMF RI results, FMC and Simplot requested and EPA agreed to a significant reduction in the groundwater analytical laboratory parameter list for the CERCLA groundwater monitoring at the site. The reduced CERCLA parameter list has been used for FMC's routine CERCLA groundwater monitoring program since 1994 following EPA's approval of the reduction.

As further described in the GWCCR, EPA has periodically requested and FMC has performed groundwater monitoring events with "expanded" analytical parameter lists that revisited many of the original CERCLA groundwater investigation long-list parameters and several groundwater

analytical parameters that were not analyzed during the EMF RI. EPA most recently requested that FMC perform an expanded analytical parameter list during the second quarter 2008 (2Q08) CERCLA ground water monitoring event. Prior to finalizing the analytical parameter list for the 2Q08 event, FMC submitted a rationale for the routine and proposed expanded laboratory parameter list. A copy of FMC's proposed 2Q08 CERCLA monitoring event, April 25, 2008 is included as Appendix A.

The results from the 2Q08 CERCLA and all previous expanded groundwater monitoring event are presented and discussed in the GWCCR. The FMC-related constituents in groundwater are identified in the GWCCR and reprinted below:

> "The supplemental sampling events provided additional results, consistent with the EMF RI, that the following constituents are FMC-related contaminants in groundwater:
>
> - Common Ions: Potassium, chloride and sulfate
> - Nutrients and Fluoride: Ammonia, nitrate, total phosphorus / orthophosphate and fluoride;
> - Metals: Arsenic, boron, manganese, selenium, and, in the eastern central plant and joint fenceline areas, vanadium.
>
> Supplemental post-RI sampling events identified the additional FMC-related groundwater contaminants as total cyanide and elemental phosphorus. These inorganic constituents were not evaluated as potential groundwater COPCs during the EMF RI.
>
> Supplemental sampling events for expanded metals, organic compound and radionuclide analytical parameters have provided further evidence supporting the findings of the EMF RI that the following constituents are not FMC-related contaminants in groundwater:
>
> - Metals: aluminum, antimony, beryllium, cadmium, copper, lead, molybdenum, mercury, silver, thallium and zinc;
> - Organic Compounds; and
> - Radionuclides.
>
> Supplemental sampling did not indicate that total uranium is a FMC-related constituent in groundwater. Elevated uranium (and gross alpha activity associated with the uranium 238 and 234 isotopes) in joint-fenceline area wells are more likely associated with naturally-occurring uranium in volcanic bedrock units within which these wells are screened."

Consistent with the recommendations in the GWCCR, the routine groundwater monitoring for the FMC Plant OU focuses on arsenic as the risk-driving groundwater constituent of concern

(COC), the additional groundwater COCs fluoride, nitrate and selenium, and the site-related indicator parameters potassium, total phosphorus / orthophosphate, chloride and sulfate with the broadest FMC-related groundwater impact.

Additionally, periodic expanded monitoring events will include the other FMC Plant OU groundwater COCs manganese and vanadium that are localized within the broader FMC-related impact and the FMC Plant OU source related constituents ammonia, boron and total cyanide that are not significant risk-drivers. Elemental phosphorus is identified as a FMC Plant OU groundwater COC, but is localized and only consistently detected above its CV in monitoring wells 108 and 122. As these wells are already routinely (semiannually) sampled and analyzed for elemental phosphorus under FMC's RCRA groundwater monitoring program, elemental phosphorus is not separately specified as a parameter under the interim CERCLA groundwater monitoring program.

The routine CERCLA groundwater monitoring laboratory analytical parameters are presented in Section 3.4.1 and periodic expanded groundwater parameters are presented in Section 3.4.2.

3.4.1 Routine Groundwater Monitoring Laboratory Analytical Parameters

Groundwater monitoring will be conducted in accordance with the FSP and QAPP presented as Attachments A and B in this document. The wells will be sampled and analyzed during each semiannual monitoring event for:

- Common ions – chloride, potassium, and sulfate.
- Metals – arsenic and selenium.
- General water quality –fluoride, nitrate, and total phosphorus.

3.4.2 Expanded Groundwater Monitoring Laboratory Analytical Parameters

Groundwater monitoring will be conducted in accordance with the FSP and QAPP presented in Attachments A and B in this document. The wells will be sampled and analyzed for an expanded laboratory parameter list every five years during the second quarter monitoring event, beginning with the second quarter 2012 [2Q12] monitoring event. The laboratory parameter list for these expanded monitoring events will include the routine and additional parameters (underlined below), as follows:

- Common ions – chloride, potassium, and sulfate.
- Metals – arsenic, selenium, <u>manganese</u>, <u>boron</u>, and <u>vanadium</u>.
- General water quality – <u>total ammonia</u>, fluoride, nitrate, and total phosphorus.
- Other parameters - <u>total cyanide</u>.

4.0 EVALUATION OF DATA

This section provides a description of the data evaluations that will be performed annually for the groundwater chemistry results from the CERCLA groundwater monitoring well network. Section 4.1 describes the evaluation of water level (potentiometric) data. Section 4.2 describes the qualitative evaluation of field and laboratory parameter results. Section 4.3 describes the quantitative (statistical) evaluation that will be performed annually for specific indicator parameter results from the CERCLA groundwater monitoring well network. Section 4.4 summarizes the data evaluation methodologies utilized for the RCRA and Calciner Pond Remedial Action monitoring programs and integration of those programs in evaluating the results from the CERCLA monitoring program on an FMC Plant OU-wide basis. The CERCLA groundwater monitoring program results and evaluations will be reported annually to EPA as described in Section 5.

4.1 WATER LEVEL MEASUREMENTS

As described in the GWCCR, groundwater levels and flow direction at the site are very stable and have not changed significantly over the 18 years of site-wide groundwater monitoring initiated during the EMF RI. There are seasonal water level fluctuations in the Michaud Flats, typically on the order of 2 to 4 feet, which may be associated with irrigation withdrawal and recharge patterns. Overall, the water levels indicate no long-term decrease in water levels at the site. Water levels in the shallow and deep wells have typically fluctuated within 4 to 8 feet between maximum and minimum measured levels over the 15 to 18 year period of monitoring for most of the wells. Maximum water levels were generally observed in the mid- to late 1990s during a cycle of average and above average regional precipitation during the monitoring period for most wells. Minimum water levels were typically observed in the 2001 and 2002 period that coincided with several years of significantly below average precipitation in the region.

Although there have been no significant changes observed since the Simplot extraction system began operation in 2003 and has expanded from 2003 to 2009, the final operating configuration and flows may create localized changes to the flow direction and gradient in the Joint Fenceline Area. In addition, Simplot's management of the gypstack (expansion of the upper gypstack toward the south) has led to changes in groundwater levels in certain wells located at the joint fenceline and, although not dramatic, has altered the groundwater flow direction and gradient in the southern portion of the Joint Fenceline Area. Simplot has recently submitted a Remedial Action Plan (Simplot, July 2009) that, among other actions, includes lining the gypsum stack over a mutli-year period with a target completion in 2015. This project also has the potential to change groundwater flow direction and gradient in the Joint Fenceline Area over time.

Cumulative hydrographs will be prepared (updated annually) with the quarterly water level data for each of the interim CERCLA groundwater wells (hydrographs are also prepared and presented in the annual RCRA Groundwater Monitoring Assessment and the annual Calciner Pond Remedial Action Groundwater Monitoring Report for those programs). The quarterly site-wide groundwater level data (collected collectively for the CERCLA, RCRA and Calciner Pond

Remedial Action groundwater monitoring programs) will be used to generate quarterly potentiometric maps. The hydrographs and potentiometric maps will be compared to prior years water levels to evaluate potential changes in site-wide groundwater levels that may be related to multi-year precipitation patterns and/or potential localized changes in flow direction related to Simplot's groundwater extraction system and management of the gypstack.

4.2 QUALITATIVE EVALUATION OF FIELD AND LABORATORY PARAMETER RESULTS

The field parameters and laboratory analytical results for each monitoring event will be evaluated to determine whether the data are generally consistent with historical results or if the data indicate potential outliers or temporal or spatial trend. The qualitative evaluation of the results is described below.

Field Parameters

Historically the dissolved oxygen, oxidation-reduction potential (ORP), turbidity and temperature results for the interim CERCLA well network, while valuable for interpreting the hydrogeochemistry at the site, have been relatively consistent and are not particularly useful for evaluating changes in the spacial extent of FMC-impacted groundwater. Thus, these parameters will only be qualitatively reviewed against prior data for comparability.

The pH and specific conductance (SC) results are valuable for interpretation of FMC and non-FMC impacts to groundwater. Time series graphs for pH and SC will be prepared for each of the CERCLA wells to visually assess potential trends and evaluate potential data inconsistencies or outliers. In the event that a potential trend is visually apparent, the data for the parameter and well may be statistically tested for trend using the same methodology described in Section 4.2.

Laboratory Analytical Constituents

Historically the water quality constituents chloride, fluoride and nitrate results for the interim CERCLA well network, while valuable for interpreting the hydrogeochemistry at the site, have been relatively consistent and are not particularly useful for evaluating changes in the spatial extent of FMC-impacted groundwater. Thus, these constituents will only be qualitatively reviewed against prior data for comparability.

Potassium, sulfate, total phosphorus (and historic orthophosphate results), arsenic and selenium results are valuable indicator parameters for interpretation of FMC and non-FMC impacts to groundwater. Time series graphs for these constituents will be prepared for each of the CERCLA wells to assess potential trends and evaluate potential data inconsistencies or outliers.

The results for the northern perimeter monitoring wells 515, TW-11S, 524 and 525 and downgradient monitoring well 502 that historically have shown minimal or no impact from FMC sources to groundwater will be compared to the representative (or background) concentrations and comparative values (CVs) for the FMC Plant OU. The groundwater representative concentrations and CVs were assembled and presented in Table 4.2-1 of the GWCCR. The

representative concentrations and CVs for the interim CERCLA groundwater monitoring routine and expanded parameters are shown on Table 4-1. The comparison of monitoring results to the representative concentrations and CVs will be used to assess the status of these wells (e.g., remain unimpacted or indication of impact).

In addition to this qualitative review of the time series graphs, the potassium, sulfate, total phosphorus (and historic orthophosphate results), arsenic and selenium results from each of the interim CERCLA wells will be tested for trend annually as described below in Section 4.3.

4.3 QUANTITATIVE (STATISTICAL) EVALUATION OF RESULTS

As described in Section 1, this interim CERCLA groundwater monitoring plan is not (and cannot be) designed to evaluate the performance of CERCLA remedial action(s) at the FMC Plant OU. Rather, one of the objectives of the interim CERCLA monitoring program is to evaluate potential changes and/or trends in site-related groundwater constituents. In order to meet this objective, in addition to the qualitative evaluations described above in section 4.2, this section describes the quantitative (statistical) evaluation of the CERCLA monitoring program results for potential trends.

Selection of the statistical method was based on the following factors: 1) the CERCLA well network does not monitor a "single" unit or source area so comparison of upgradient (background) to downgradient wells (inter-well comparison) is not appropriate, 2) the majority of the CERCLA monitoring network wells have been site impacted and, as described in the GWCCR, trends may be present, and 3) the unimpacted wells (523, 515, 502, TW-11S, 524 and 525) within the network should not be presumed not to show a trend and the data sets for unimpacted wells contain a relatively high proportion of undetected results.

As stated in "*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*" (EPA, March 2009), the Mann-Kendall Test for Trend is summarized as follows:

> **"Basic purpose:** Method for detection monitoring and diagnostic tool. It is used to identify the presence of a significant (upward) trend at a compliance point or any trend in background data.
> **Hypothesis tested:** H_0 — No discernible linear trend exists in the concentration data over time. H_A — A non-zero, (upward) linear component to the trend does exist.
> **Underlying assumptions:** Since the Mann-Kendall trend test is a non-parametric method, the underlying data need not be normal or follow any particular distribution. No special adjustment for ties is needed.
> **When to use:** Use a test for trend when 1) interwell tests are inappropriate so that intrawell tests are called for, and 2) a control chart or intrawell prediction limit cannot be used because of possible trends in intrawell background. A trend test can be particularly helpful at sites with recent or historical contamination where it is uncertain if intrawell background is already contaminated. An upward trend in these cases documents changing concentration levels more accurately than either a control chart or intrawell prediction limit, both of which assume a stationary background mean concentration.

Steps involved: 1) Sort the data values by time of sampling/collection; 2) consider all possible pairs of measurements from different sampling events; 3) score each pair depending on whether the later data point is higher or lower in concentration than the earlier one, and sum the scores to get Mann-Kendall statistic; 4) compare this statistic against an α-level critical point; and 5) if the statistic exceeds the critical point, conclude that a significant upward trend exists. If not, conclude there is insufficient evidence for identifying a significant, non-zero trend.
Advantages/Disadvantages: The Mann-Kendall test does not require any special treatment for nondetects, only that all non-detects can be set to a common value lower than any of the detects. The test is easy to compute and reasonably efficient for detecting (upward) trends. Exact critical points are provided in the Unified Guidance for $n <= 20$; a normal approximation can be used for $n > 20$)."

In consideration of the factors described above, the arsenic, potassium, total phosphorus / orthophosphate, sulfate and selenium results from the interim CERCLA wells will be quantitatively evaluated using the Mann-Kendall test for trend. The Mann-Kendall test for trend will be performed at the 95% confidence level ($\alpha = 0.05$). The test for trend will be performed on the CERCLA well network to evaluate whether there are upward trends in individual wells within these areas on the site:

- On-Plant Site wells: 134, 139, 151, 159 and 145 (in the joint fenceline area);
- Plant Site downgradient wells: 111, 146, 110 and TW-9S;
- Wells downgradient from the FMC and Simplot Plant sites: 517 and TW-12S; and,
- Northern perimeter wells: 523, 515, 502, TW-11S, 524 and 525.

The test for trend results for the CERCLA well network will be utilized in conjunction with the evaluations of the RCRA and Calciner Pond Remedial Action groundwater monitoring programs to assess the FMC Plant OU-wide groundwater conditions and any quality trends as described in Section 4.4 below.

4.4 INTEGRATION WITH OTHER FMC GROUNDWATER MONITORING PROGRAMS

The CERCLA groundwater monitoring program results will be evaluated on a well-specific basis and as groups for specific areas of the site as described in Sections 4.2 and 4.3 above; however, in order to assess the results on an FMC Plant OU-wide basis, output from FMC's RCRA and Calciner Pond Remedial Action monitoring programs will be utilized as inputs to the CERCLA groundwater monitoring evaluations. The RCRA and Calciner Pond Remedial Action groundwater monitoring program results are evaluated pursuant to their respective groundwater monitoring plans. A brief description of the data evaluations performed pursuant to the RCRA (FMC, 1999 and updates) and Calciner Pond Remedial Action (FMC, November, 2008) groundwater monitoring plans is provided in Sections 4.4.1 and 4.4.2, respectively.

While the interim CERCLA groundwater monitoring data evaluations and assessment will utilize data and results of the evaluations from the Calciner Pond and RCRA programs, this plan is not intended to modify or replace the requirements under the Calciner Pond Groundwater Monitoring Plan or RCRA post-closure sampling and analysis plans, including the reporting requirements under those plans respectively. Figure 4-1 shows a flow chart that illustrates the procedure for integration of the Calciner Pond Remedial Action and RCRA groundwater monitoring program output with the interim CERCLA monitoring evaluations. In addition to the FMC groundwater monitoring program data, the Simplot groundwater monitoring data will be reviewed and evaluated as part of the overall assessment of FMC Plant OU-wide groundwater quality and any trends, primarily in the joint fenceline area and in the area downgradient from both FMC's and Simplot's plant sites.

4.4.1 Summary of RCRA Annual Groundwater Assessment

The annual results from the RCRA monitoring well network are evaluated qualitatively and quantitatively. The field parameters and laboratory analytical results for the quarterly monitoring events within the calendar year are evaluated to determine whether the data are generally consistent with historical results or if the data indicate potential outliers or temporal or spatial trends. In addition to the qualitative data evaluations, the arsenic, fluoride and selenium results are quantitatively (statistically) evaluated on a WMU-by-WMU basis to determine the status of each WMU for the monitoring year.

As recommended by the EPA (James Brown, Office of Solid Waste, May 5, 1993), and consistent with the EPA's guidance documents for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (EPA, 1989, 1992, March 2009), the indicator constituent (arsenic, fluoride and selenium) concentrations are analyzed using a defined set of statistical procedures: the non-parametric Mann-Whitney U-test (rank-sum test) to compare the central tendency (median) of two data sets, and a comparison of mean concentrations. Details of the Mann-Whitney method are provided in the "RCRA Interim Status Groundwater Monitoring Assessment Report" (FMC, August 1993). Statistical testing procedures are as follows:

Test 1) For each WMU, the arsenic, fluoride, and selenium concentrations in upgradient wells are compared to those in the downgradient wells using the Mann-Whitney U-test (also known as the Wilcoxon rank-sum test). The test is performed using a significance level $\alpha = 0.05$ (i.e., if the test yields a p-value less than 0.05, the null hypothesis is rejected and the median concentrations of upgradient and downgradient wells is considered to be significantly different). The α-value of 0.05 sets the Type I error rate at 5%; that is, the risk that the medians will be considered significantly different through statistical testing, even though they are not is 5%. In many cases, constituent concentrations are expected to be higher in the downgradient wells because of the presence of former unlined ponds (the old phossy ponds [Remediation Unit 22b as defined in the SRI Report, MWH, 2009]) underlying or adjacent to certain WMUs. Results showing statistically higher downgradient concentrations using this analysis do not necessarily indicate current impacts from the WMUs, and in certain cases may instead be

attributable to prior practices at the former ponds. Consequently, an additional test (Test 2) is also conducted for downgradient wells for each WMU.

Test 2) For each downgradient well, the current monitoring year mean concentrations of arsenic, fluoride, and selenium are compared to pre-monitoring year mean concentrations. If the current monitoring year mean concentrations are less than or equal to pre-monitoring year mean concentrations, the concentrations of the measured constituent are not increasing at that well, therefore presumably no leakage of contaminants from the WMU is occurring. If the results of Test 1 indicate that concentrations in downgradient wells are significantly higher than those of upgradient wells, and the results of Test 2 indicate that the current monitoring year mean is higher than the pre-monitoring year mean for any individual downgradient well, then Test 3 is conducted.

Test 3) The Mann-Whitney U-test is performed for downgradient wells in the given WMU to compare concentrations observed in the current monitoring year with concentrations observed in previous years (pre-monitoring year). This test is intended to determine if data for a constituent shows a statistically significant increase through time by comparing the median concentrations of the current monitoring year and previous year data sets. As with Test 1, Test 3 is performed using a significance level $\alpha = 0.05$.

The RCRA annual assessment reports include quarterly groundwater water level data and contour maps, cumulative hydrographs for wells associated with each monitored WMU, overall (qualitative) assessment of the field and laboratory results, the results of the statistical tests and time series graphs for arsenic, fluoride and selenium for each monitored WMU, and an assessment of the status of the monitored WMUs.

4.4.2 Summary of Calciner Pond Remedial Action Groundwater Annual Evaluation

The annual results from the Calciner Pond monitoring well network are evaluated qualitatively and quantitatively as described in the Calciner Pond Remedial Action Groundwater Monitoring Plan (FMC, November 2008). A brief summary of those evaluations is presented below.

The field parameters and laboratory analytical results for the semi-annual monitoring events within the calendar year are evaluated to determine whether the data are generally consistent with historical results or if the data indicate potential outliers or temporal or spatial trends. In addition to the qualitative data evaluations, the arsenic, potassium, total phosphorus / orthophosphate, sulfate and selenium results are quantitatively (statistically) evaluated for the monitoring year.

The Mann-Kendall Trend Analysis procedure (see Section 4.3 for description) is used to assess the presence of trends in the constituent levels for the Calciner Pond Remedial Action groundwater monitoring wells (161, 164, 142, 190, 189, 143 and 136). The test is suitable for data that do not follow a normal distribution, and supports multiple observations per time period. Comparisons are made at the 95% confidence level.

In addition to the test for trend results, a source area evaluation is performed that includes evaluation of the sulfate to chloride ratio (SO4:Cl) and potassium to chloride ratio (K:Cl) in the Calciner Pond wells in comparison to the ratios determined for the major sources identified in the joint fenceline area, namely the calciner ponds area subject to the Calciner Pond Remedial Action and the Simplot gypsum stack.

The Calciner Pond Remedial Action annual groundwater monitoring reports include quarterly groundwater water level data and contour maps, cumulative hydrographs for the Calciner Pond groundwater well network, overall (qualitative) assessment of the field and laboratory results, the results of the statistical tests and time series graphs for arsenic, potassium, total phosphorus / orthophosphate, sulfate and selenium, and the source evaluation (ion ratios), and an assessment of the status of the Calciner Pond Remedial Action area.

4.4.3 Integration of RCRA / Calciner Pond Program Results with CERCLA Evaluations

As stated in Section 1, one of the objectives of the interim CERCLA monitoring program is to evaluate any changes and/or trends in groundwater conditions on an OU-wide basis. The results of the statistical analysis of the interim CERCLA groundwater monitoring data will be further evaluated consistent with the project data quality objectives step 5 - development of decision rules as described in the Quality Assurance Project Plan (QAPP, Attachment B). The evaluations (or decision rules) for the CERCLA program results are designed as a series of logical steps that include consideration of the results from the RCRA, Calciner Pond and Simplot groundwater monitoring programs.

As described in Section 4.3, the Mann-Kendall test for trend will be used to determine if there are upward trends in arsenic, potassium, total phosphorus / orthophosphate, sulfate and selenium concentrations in samples collected from the CERCLA well network:

- On-Plant Site wells: 134, 139, 151, 159 and 145 (in the joint fenceline area);
- Plant Site downgradient wells: 111, 146, 110 and TW-9S;
- Wells downgradient from the FMC and Simplot Plant sites: 517 and TW-12S; and,
- Northern perimeter wells: 523, 515, 502, TW-11S, 524 and 525.

If upward trends are detected for any parameter and well(s), additional evaluation will be performed to assess the cause and source of the upward trend(s). The additional evaluation(s) will rely on the qualitative and quantitative data evaluations from all of the groundwater monitoring programs, including Simplot's, as follows:

On-Plant Site wells: Any upward trend(s) at well 139, 134, 151 and/or 159 will be compared to the results from the RCRA annual assessment report to assess whether the tends are related to releases from the closed RCRA ponds or more likely related to the former unlined phossy ponds in the western ponds area. Any upward trend(s) at well 145 will be compared to the results from the Calciner Pond annual groundwater monitoring report to assess whether the trend(s) is consistent with trends observed at the other wells in the joint fenceline area.

Plant Site downgradient wells: Any upward trend(s) at well 111 and/or 146 will be compared to the results from the RCRA annual assessment report to assess whether the tends are related to releases from the closed RCRA ponds or more likely related to the former unlined phossy ponds in the western ponds area. Any upward trend(s) at well 110 will be compared to the results from the Calciner Pond annual groundwater monitoring report to assess whether the trend(s) is consistent with trends observed at the other wells in the joint fenceline area.

Wells downgradient from the FMC and Simplot Plant sites: Any upward trend(s) at well 517 and/or TW-12S will be compared to the results from the RCRA, Calciner Pond and Simplot groundwater monitoring results to assess the likely cause and source of the increasing trend.

Northern perimeter wells: Any upward trend(s) at well 523, 515, 502, TW-11S, 524 and 525 will first be assessed to determine if the trends are related to undetected results at higher detection limits. If the trends are not related to elevated undetected results, the current year concentrations will be compared to the representative (background) values (Michaud or Bannock 95th percentile representative values as appropriate based on the hydrogeochemistry at the monitoring well of interest) per Table 4-1 of the GMP to determine whether there is an indication that the well could be impacted by the EMF Site or other non-EMF source(s). If the result(s) exceed the representative value(s), the results will be compared to the concentration and trend(s) observed at the nearest cross-gradient well(s) within the EMF-impacted area to assess whether the changes are EMF related or more likely related to non-EMF sources.

Depending trend test results for the CERCLA wells and the integrated evaluation method described above. Additional action(s) may be undertaken including:

1. Re-sampling monitoring well(s) within the CERCLA, RCRA and/or Calciner Pond Remedial Action groundwater monitoring well networks may be performed to confirm parameter concentration that may have resulted in a false positive outcome.

2. If the upward trend(s) is confirmed and is likely attributable to the closed RCRA ponds or Calciner Pond Remedial Action area, further evaluation and potential mitigation plan(s) will be performed under those programs.

3. If the upward trend(s) is likely attributable to FMC source areas identified for CERCLA remedial action, ensure the remedial design addresses mitigation of identified and potential future sources of groundwater impacts that could exceed the CVs (MCLs, secondary standards or RBCs).

4. If the upward trend(s) is likely attributable to Simplot sources, no FMC action is necessary.

TABLE 4-1. Interim CERCLA Groundwater Monitoring Parameter Representative Concentrations and Comparative Values

ANALYTE	Michaud 95th Percentile (a)	Bannock 95th Percentile (a)	Groundwater Comparative Values (CVs) (b)	Source of Groundwater CV (c)
COMMON IONS (mg/l)				
Chloride	192.90	52.42	250	Secondary Standard
Potassium	12.72	10.52		
Sulfate	72.57	43.40	250	Secondary Standard
PHYSICAL PARAMETERS				
Spec.Conductivity (umhos/cm)	1136	569		
pH	(d)	(d)	6.5 to 8.5	Secondary Standard
Temperature (degrees Celcius)	(d)	(d)		
Redox (mV)	(d)	(d)		
NUTRIENTS AND FLUORIDE (mg/l)				
Ammonia (NH3 as N)	0.50	0.50		
Nitrate (NO3 as N)	5.52	1.60	10	MCL
Orthophosphate (PO4 as P)	0.06	0.13		
Phosphorous	0.33	0.31		
Fluoride	0.80	0.60	4	MCL
METALS (mg/l)				
Arsenic	0.0141	0.0170	0.01	MCL
Boron	0.2935	0.3078	7.3	PRG
Manganese	0.0518	0.0201	0.05	Secondary Standard
Selenium	0.0057	0.0055	0.05	MCL
Vanadium	0.0745	0.1000	0.18	PRG
Other Inorganics				
Total Cyanide	(e)	(e)	0.2	MCL

(a) The Bannock and Michaud representative concentrations are 95th percentile values for pre-1994 data as presented in Table 4.4-1 in the EMF RI Report with the exception of the representative arsenic concentration that is a 95% Upper Prediction Limit as described in Section 4.4 of the Groundwater Current Conditions Report for the FMC Plant OU.

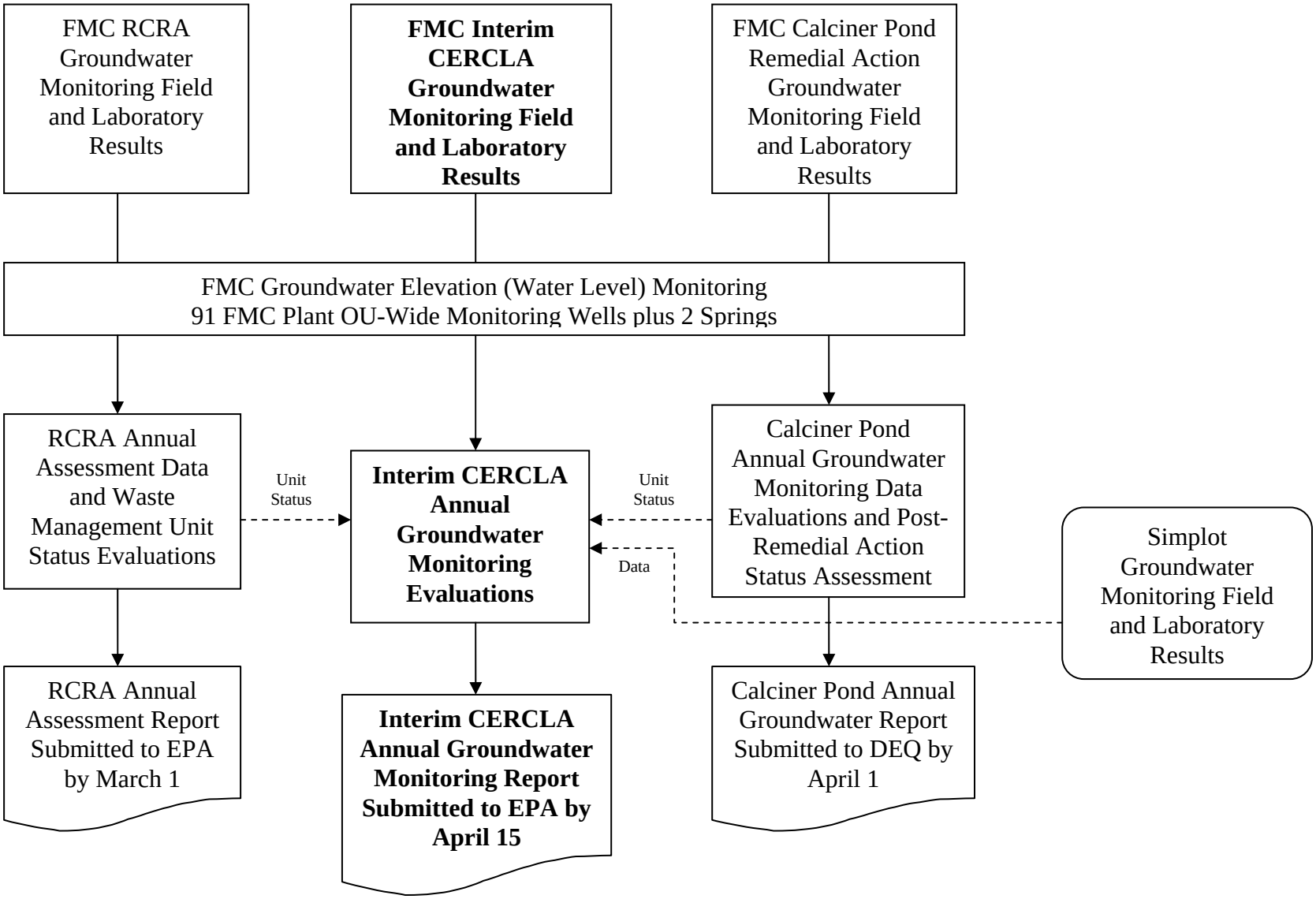
(b) All values are in milligrams per liter (mg/l) unless the units are otherwise specified.

(c) Secondary Standard per National Secondary Drinking Water Regulations; MCL means Maximum Contaminant Level per National Primary Drinking Water Regulations; PRG means Preliminary Remedial Goal for Tap Water per EPA Region VI PRG Table (3/8/2008).

(d) Representative values were not calculated for pH, temperature and redox during the EMF RI.

(e) These parameters were not analyzed or detected during the EMF RI so no representative concentrations were calculated during the EMF RI.

FIGURE 4-1. FLOW CHART ILLUSTRATING INTEGRATION OF THE FMC GROUNDWATER MONITORING PROGRAMS INTO THE INTERIM CERCLA GROUNDWATER MONITORING EVALUATION FOR THE FMC PLANT OU



5.0 REPORTING PROCEDURES

Annual reports will be submitted to EPA by April 15 of the year following the monitoring calendar year (e.g., the 2010 Interim CERCLA Groundwater Monitoring Report will be submitted to EPA by April 15, 2011). These annual reports will contain the following information:

- A compilation of field sampling (e.g. water elevation levels) and laboratory analytical results for the groundwater monitoring program described in this plan.
- FMC Plant OU-wide groundwater elevations displayed on contours maps and updated hydrographs for the interim CERCLA monitoring well network as described in Section 4.1.
- An assessment of data quality and usability.
- An evaluation of groundwater quality that will include:
    - A summary of general chemistry results as described in Section 4.2;
    - Results of trend tests for arsenic, potassium, total phosphorus / orthophosphate, sulfate and selenium as described in Section 4.3; and
- An assessment of the CERCLA groundwater monitoring results including results and output from FMC's RCRA and Calciner Pond Remedial Action groundwater monitoring programs and Simplot's groundwater monitoring data in a comprehensive manner that evaluates potential changes and/or trends in site-wide groundwater at the FMC Plant OU as described in Section 4.4.3.

The annual report will also include the monitoring year's groundwater levels, field parameter and laboratory analytical results in an electronic format (e.g., Microsoft Excel spreadsheet). The data validation and usability reports for the monitoring year will be attached in an electronic format (e.g., Adobe Acrobat).

6.0 REFERENCES

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FMC Idaho LLC (FMC), November 2008. "Calciner Pond Remedial Action Groundwater Monitoring Plan," May 2008, Revised November 2008.

FMC, 1999. "RCRA Interim Status Groundwater Monitoring Plan", Bechtel Environmental, August 1999; as updated in the RCRA Post-Closure Plans as follows:

- Pond 9E post-closure plan, January 2000;
- Slag Pit Sump post-closure plan, September 2001;
- Pond 8E, Phase IV Ponds and Pond 15S post-closure plans, May 2002;
- Pond 16S post-closure plan, July 2003; and,
- Pond 17 and Pond 18 Cell A post-closure plans, August 2004.

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APPENDIX A

FMC CERCLA GROUNDWATER MONITORING PROGRAM

2Q2008 SPECIAL SAMPLING AND ANALYSIS EVENT

MARCH 28, 2008, REVISED APRIL 25, 2008

FMC Idaho LLC
P.O. Box 4111
Pocatello, ID 83205

208.235.8212 phone
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FMC Corporation

Via email and first class mail

April 25, 2008

Ms. Kira Lynch
Remedial Program Manager (M/S ECL-113)
U.S. Environmental Protection Agency Region 10
1600 Sixth Avenue
Seattle, Washington 98101

Subject: FMC Groundwater Monitoring Program, 2Q2008 CERCLA Special Sampling and Analysis Event
FMC Idaho LLC, Pocatello, Idaho

Dear Ms. Lynch:

On March 28, 2008 FMC submitted a proposal to conduct a "special" CERCLA groundwater monitoring event to be conducted concurrently with the routine second quarter 2008 (2Q2008) groundwater monitoring programs at the FMC Plant OU. FMC's proposal presented the results of an evaluation of the groundwater database for the FMC Plant OU that focused on the ROD-specified groundwater chemicals of concern (COCs), recommended supplemental analytical parameters and an additional set of groundwater wells that will be included in the 2Q2008 groundwater monitoring event at FMC.

Based on the April 14 and 18, 2008 teleconferences between FMC and the Agencies during which FMC's March 28 proposal was discussed, FMC has revised the 2Q2008 CERCLA groundwater monitoring special event to: 1) add ORP as a field parameter, 2) add mercury as a laboratory parameter, and 3) replace orthophosphate with total phosphorus as a laboratory parameter for the 2Q2008 event. The enclosed 2Q2008 Special Sampling and Analysis Event summary including Tables 1 and 2, and the SAP Addendum (April 2008) Table 3-4a, Table 3-5a, Table 5-1a, Table 5-5a, Table 7-1a, and Figure 1 represent an the addendum to the EMF RI Sampling and Analysis Plan (SAP) for this 2Q2008 special groundwater monitoring and analysis event.

FMC's groundwater sampling contractor is currently scheduled to conduct the 2Q2008 groundwater monitoring event at FMC during the week of May 19, 2008. Therefore, we request EPA approval of the 2Q2008 Special Sampling and Analysis Event SAP

addendum by May 12, 2008 so that the logistics for the special event can be finalized one week in advance of initiating the field work.

As stated in the summary, the results of this event will be added to the cumulative groundwater database and reported to EPA in a groundwater current conditions report for the FMC Plant OU that will be provided in mid-August 2008.

Please feel free to contact me at (215) 299-6700 should you have questions regarding this information.

Sincerely,

Barbara Ritchie
FMC Corporation

Enclosures

cc: Groundwater Working Group 3 Route List (email only)

FMC CERCLA Groundwater Monitoring Program
2Q2008 Special Sampling and Analysis Event
March 28, 2008
Revised April 25, 2008

In response to EPA questions regarding FMC's voluntary CERCLA groundwater monitoring program analytical list, FMC has proposed a "special" groundwater monitoring event that will be conducted concurrently with the routine second quarter 2008 (2Q2008) RCRA, Calciner Ponds and FMC voluntary CERCLA groundwater monitoring programs. This summary presents the results of an evaluation of the groundwater database for the FMC Plant OU that focuses on the ROD-specified groundwater chemicals of concern (COCs), recommended supplemental analytical parameters and an additional set of groundwater wells that are proposed to be included in the 2Q2008 groundwater monitoring event at FMC.

This summary has been revised to add ORP as a field parameter, mercury as a laboratory parameter, and total phosphorus will replace orthophosphate as a laboratory parameter for the 2Q2008 event based on the April 14 and 18, 2008 teleconferences between FMC and the Agencies as described in more detail below. This summary and the attached tables and figure represent an addendum to the EMF RI Sampling and Analysis Plan (SAP) for this 2Q2008 special groundwater monitoring and analysis event. The attached SAP Addenda (April 2008) specific to the 2Q2008 event are: Table 3-4a, Table 3-5a, Table 5-1a, Table 5-5a, Table 7-1a, and Figure 1.

The results of this event will be added to the cumulative groundwater database and reported to EPA in a groundwater current conditions report for the FMC Plant OU that will be provided in mid-August 2008.

Evaluation of Existing Groundwater Data

As FMC has stated in the past, the routine analytical parameters, especially arsenic and potassium, remain the most valuable indicator parameters for monitoring the extent and any trends in groundwater quality related to the identified groundwater impacts at the FMC Plant OU. As documented in Section 4.4 of the Remedial Investigation (RI) Report, arsenic concentrations above representative concentrations essentially define the outermost extent of the EMF Site groundwater impact, whereas groundwater COCs such as boron, fluoride, manganese, nitrate and selenium above representative concentrations have been identified in smaller "subareas" within the larger arsenic groundwater impact. Thus, routine groundwater monitoring for arsenic appropriately focuses on the indicator parameter that delineates the broadest impact.

FMC performed a detailed review of the historic groundwater database focused on the EMF Site ROD-identified groundwater chemicals of concern (COCs) to develop a supplemental analytical parameter list for the 2Q2008 special event. The evaluation

was performed on groundwater data from FMC's monitoring wells (100-series and TW- wells), RI "off-site" wells (500-series wells), and Batiste Springs for all years through the second quarter 2007 from the FEDS database. This evaluation did not include any EPA, IDEQ or Shoshone-Bannock Tribes data from their collocated sampling as described in "Summary of FMC'S Post-Remedial Investigation (1995-2007) Groundwater Monitoring Programs and Supplemental Groundwater Sampling and Analysis Events," February 2008. FMC's evaluation of the groundwater parameters is summarized in the attached Table 1 Summary of FMC's Evaluation of Groundwater Chemicals of Concern.

The supplemental analytical parameters for the 2Q2008 event were selected based on a review of the findings of the RI and review of the cumulative database utilizing the following criteria:

1. The groundwater COC was detected above representative concentrations in monitoring wells located downgradient from FMC source areas (e.g. beryllium was not detected above representative concentrations in any FMC or 500-series well downgradient from FMC source areas, but was detected in Simplot well 318).
2. The groundwater COC was detected at concentrations greater than the Maximum Contaminant Limit (MCL) or EPA-calculated groundwater Risk-Based Concentration (RBC) in greater than 5% of the sample results and the detection limits for those COC results were routinely below the MCL/RBC.
3. The groundwater COC was detected at concentrations greater than the surface water comparative value (e.g., Water Quality Criteria) in greater than 5% of the sample results and the detection limits for those COC results were routinely below the comparative criteria.
4. The radiological parameters radium-226 and radium-228 were selected based on the second criteria above, and gross alpha is included to supplement the database particularly for wells upgradient and downgradient from the FMC Plant OU.
5. The groundwater parameter was not analyzed during the RI and has been subsequently detected above its comparative value in groundwater at the FMC Plant OU (elemental phosphorus at wells 108 and 122 and total cyanide at wells 131 and 168).
6. No groundwater data is available for total uranium for the FMC Plant OU and downgradient wells so it has been included to fill a perceived data gap.

Due to the size of Table 1, the results of the evaluation are presented on the far right-hand column entitled "Selected for 2Q2008 'Special' GW Monitoring" on pages 3 and 4 of Table 1.

Discussion during April 14, 2008 FMC-Agencies Teleconference

During the teleconference between FMC and the Agencies on April 14, 2008 to discuss comments on FMC's March 28, 2008 proposed 2Q2008 special groundwater monitoring event, EPA requested that FMC include one additional field parameter, four additional laboratory parameters (metals), and to include analysis for total phosphorus (rather than orthophosphate) for the 2Q08 event. A summary of the discussion and resolution of EPA's requested additional parameters follows:

Additional field parameter: EPA requested inclusion of ORP as a field parameter. EPA acknowledged that dissolved oxygen is appropriate as an indicator of oxidation conditions and stability of well-purge / formation water prior to sampling, but also requested ORP to provide additional information on reducing conditions for those wells where dissolved oxygen is low or undetectable. FMC agreed to include ORP as a field parameter for the 2Q08 event.

Additional laboratory parameters: EPA requested inclusion of four metals – beryllium, chromium, nickel and mercury – to the laboratory parameter list. FMC pointed out the results of its evaluation, as documented on Table 1, show that none of the groundwater results for beryllium and nickel exceeded the MCL or RBC in the FMC (100-series and TW- wells) and downgradient 500-series wells, and only 2 of over 1,200 (0.2%) results exceeded the MCL for chromium. As shown on EPA's evaluation of EMF groundwater results (documented in the file entitled "mls-GW-Screen with Eco.xls," "GW Screen Alpha" worksheet, dated 2/6/08 attached to K. Lynch, EPA electronic message dated 2/6/2008, subject: Fw: GW table w/ eco benchmarks), beryllium, chromium and nickel were significantly elevated in RI groundwater samples from well 318, downgradient from Simplot's former east overflow pond, but not in the other wells presented in the evaluation. Following the discussion, the Agencies did not further pursue inclusion of these parameters in the 2Q08 event.

FMC also pointed out its evaluation results for mercury show that less than 2% of over 900 results exceeded the MCL; that 8 of the 11 results which exceeded the MCL were from well 144 that is screened in weathered volcanic lithology and the mercury in well 144 is likely naturally occurring; and that no post-RI results (from 1997 – 2001) exceeded the MCL. EPA commented that the Tribes have raised concerns regarding some of the mercury data in the EMF RI being flagged by the laboratory and asked the Tribal representatives if their collocated groundwater results indicated different results than FMC's results and evaluation. The Tribal representative indicated that they would need to review their data before responding to EPA's question. Mercury as an analytical parameter for the 2Q2008 event was taken under advisement pending additional justification and/or Tribes' data review by EPA.

Following the April 14, 2008 conference call, FMC reviewed the Tribes collocated groundwater sample results for mercury from 2001, 2004, 2005 and 2006. The Tribes groundwater results were provided by EPA in an Excel spreadsheet following the

February 12 and 13, 2008 EMF meetings. Although the spreadsheet forwarded by EPA does not include any information with which to assess the quality, validity or usability of the Tribes data, on its face, the Tribes data does not contradict but rather supports FMC's results that demonstrate mercury is not an FMC-related COC in groundwater. The Tribes results from the EPA-forwarded spreadsheet are summarized as follows:

Year	Total # Samples	# Results > MCL (Value)	Well w/ Result > MCL	FMC Result for Primary Sample	Comment
2000	20	1 (0.0021 mg/l)	168	0.0002 **U**	FMC analyzed for the same parameter list as Tribes for the 2000 collocated samples; most Tribes mercury results were not detected or near detection limit, but there appear to be data quality issues with the Tribes 2000 mercury data.
2004	14	0	None	NA	Tribes data: 11/14 < 0.0001, 3/14 values = 0.0001.
2005	20	0	None	NA	Repeated same wells as 2000, Tribes' result for well 168 = 0.0002 **U,** overall Tribes data: 19/20 = 0.0002 **U**, 1/20 = 0.0002.
2006	8	0	None	NA	Tribes data: 8/8 < 0.0002.

Following the Working Group #4 (Simplot) topics during the teleconference on April 18, 2008, FMC asked if EPA had any further information to support its rationale to include mercury as a parameter for the 2Q2008 event. EPA did not present any new information but maintained the position that since mercury is identified as a groundwater COC in the 1998 ROD it should be included to provide "current" data and could not be eliminated from further consideration without "current" data. Rather than further argue the point, FMC agreed to include mercury as a laboratory parameter for the 2Q08 event.

Total phosphorus analysis: EPA questioned the detection limit for laboratory analysis for orthophosphate of 0.1 mg/l (Table 5-1a) and suggested that a lower detection limit would be preferable. Based on the fact that the Portnuef River TMDL is based on total phosphorus and Simplot's groundwater monitoring includes total phosphorus using method 365.2 with a detection limit of 0.01 mg/l but not orthophosphate analysis, EPA requested that FMC include total phosphorus analysis in the 2Q08 event for consistence with the TMDL and Simplot. FMC noted that total phosphorus and orthophosphate data have been comparable historically (i.e., analytical results show that total phosphorus is essentially all in the orthophosphate form in groundwater wells). Based on the discussion, FMC proposed to replace orthophosphate analysis with total phosphorus analysis and would contact its laboratory to confirm method and detection limit. FMC asked if the EPA RCRA program would take issue with the substitution with respect to the RCRA groundwater program wells for this quarter. EPA's RCRA program representative accepted the

substitution. FMC will include total phosphorus for the 2Q08 event using method 6020 with a detection limit of 0.019 mg/l as indicated on the attached addendum to the EMF RI Sampling and Analysis Plan (SAP) entitled "Addendum April 2008, Table 5-1a, III. Groundwater, Analytical Methods for 2Q2008 Groundwater Monitoring Event."

Analytical Parameters for the 2Q2008 Groundwater Monitoring Event

Based on FMC's evaluation, the Agencies review and comments on FMC's proposal and in conjunction with FMC's routine groundwater monitoring program, the analytical parameters for the 2Q2008 event will include:

Routine Analytical Parameters:			
Field parameters:	General Mineral:	Metals:	Additional Parameters:
Dissolved Oxygen pH Temperature Turbidity Specific Conductance	Ammonia Chloride Fluoride Nitrate Total phosphorus [1] Sulfate	Potassium Arsenic Selenium Cadmium (RCRA only)	Elemental phosphorus (Slag Pit Sump and Pond 8S only)

Special Analytical Parameters:			
Field parameters:	Metals:	Radionuclides:	Additional Parameters:
ORP	Antimony Boron Manganese Mercury Vanadium	Gross alpha Ra-226 Ra-228	Elemental phosphorus[2] Total cyanide Total uranium

Notes:
[1] Based on March 14, 2008 conference call between FMC and the Agencies, total phosphorus analysis will replace orthophosphate analysis for the 2Q2008 event including the routine RCRA and Calciner Pond groundwater monitoring programs.
[2] Elemental phosphorus will be included as a 2Q2008 special event analyte for the following wells: 110, 111, 146, TW-9S, 502, 517, TW-11S, TW-12S, and Batiste Spring.

The analytical parameters, analytical methods and detection limits for the 2Q2008 special groundwater monitoring event are provided in the attached addendum to the EMF RI SAP Table 5-1a.

Groundwater Monitoring Wells for the 2Q2008 Event

The routine FMC groundwater programs consist of a well network that includes upgradient wells to the west and south of potential FMC sources, FMC source area specific wells, downgradient wells from the FMC plant site to Batiste Spring and wells outside the northern extent of EMF-impacted groundwater. FMC evaluated the

groundwater monitoring well network associated with its routine monitoring programs and the monitoring wells that were installed during the RI and post-RI that are not currently included in one of the routine programs. Based on the evaluation, FMC is proposing to analyze samples from 25 (of 52 total) routine wells and an additional 14 monitoring wells for the special analytical parameter list during the 2Q2008 monitoring event. The 25 routine wells were selected to include upgradient wells and source area specific wells in the western ponds area, former process areas and calciner ponds / joint fenceline area. The additional 14 wells were selected to include additional wells upgradient of potential FMC source areas (background wells), “sentry” wells historically outside the northern limit of EMF groundwater impacts, and downgradient wells between the EMF plant sites and Batiste Spring that have not been sampled within the last several years. The routine program and additional special event wells are enumerated in Table 2 and shown on the attached Figure 1 Well Locations FMC2Q2008 Monitoring Event.

TABLE 2. FMC'S ROUTINE GROUNDWATER MONITORING AND ADDITIONAL WELLS FOR THE 2Q2008 "SPECIAL" GROUNDWATER MONITORING EVENT

Area	Well Numbers [1]	Up / Downgradient	Program [2]
Pond 18 (Cell A and Cell B)	**174, 175**	U	RCRA
	154, 176, 177, 178	D	RCRA
Pond 17	**173**	U	RCRA
	171, 172, 180	D	RCRA
Pond 16S	154	U	RCRA
	147,148, **149**	D	RCRA
Pond 15S	165	U	RCRA
	113, 115, 166	D	RCRA
Phase IV ponds	**167**	U	RCRA
	104, 114, 131, 168	D	RCRA
Pond 9E	124, 113	U	RCRA
	126, **127**, 128	D	RCRA
Pond 8E	**167**	U	RCRA
	104, 114, 131, 168	D	RCRA
Pond 8S	158, **183**	U	RCRA
	155, **156**, 157	D	RCRA
Slag Pit Sump	121	U	RCRA
	108, 122, 123	D	RCRA
Batiste Spring	**Batiste Spring**	D	RCRA
Calciner Ponds	**164, 161**, 142	U	IDEQ
	136, 143, 189, 190	D	IDEQ
Upgradient FMC Plant	**101, 102, 169**	U	CERCLA
Within FMC plant	**139, 134, 145**	D	CERCLA
Northern edge FMC plant	**111, 146, 110, 112, 523, 501**	D	CERCLA
Downgradient from FMC plant toward Batiste Spring	**TW-9S, 517, 502, TW-12S, TW-11S**	D	
Outside EMF impact [3] - northern perimeter	**515, 524, 525, 516**	Cross	CERCLA

[1] Wells in red-colored BOLD font are routine wells that will be analyzed for the 2Q2008 special analytical parameter list in addition to the routine parameter list. Wells in red-colored BOLD and UNDERLINE font are the 14 additional wells for the 2Q2008 special sampling event (both routine and special parameter list).
[2] Program: RCRA = RCRA groundwater monitoring plans, IDEQ = Calciner Pond groundwater monitoring plan, CERCLA = FMC continuation of monitoring at "key" CERCLA wells.
[3] Impact is in reference to detection of arsenic, nitrate or selenium above representative levels.

TABLE 1. SUMMARY OF FMC'S EVALUATION OF GROUNDWATER CHEMICALS OF CONCERN FROM RI AND POST-RI DATA FROM FMC 100-SERIES AND TW- WELLS, 500-SERIES WELLS AND BATISTE SPRING MONITORING LOCATIONS

Remedial Investigation ANALYTES	Basis for EPA approval to eliminate from CERCLA GW monitoring [a]	Current CERCLA Monitoring [b] ANALYTES	Current RCRA Monitoring [b] ANALYTES	Post-RI "Special" GW Event [c] ANALYTES	EPA 2008 Table [d] "Yellow or Red"	ROD Table 14 GW COPCs	ROD Table 36 GW COCs	ROD GW COCs MCL or RBC [e]
COMMON IONS								
Alkalinity, bicarbonate	K and SO4 better indicators			1998, 2002				
Calcium	K and SO4 better indicators			1998, 2002				
Chloride	K and SO4 better indicators	**RETAINED**	**RETAINED**	**NA - routine analyte**				
Magnesium	K and SO4 better indicators			1998, 2002				
Potassium	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**				
Sodium	K and SO4 better indicators			1998, 2002				
Sulfate	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**				
PHYSICAL PARAMETERS								
Spec.Conductivity	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**				
pH	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**				
Temperature	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**				
Total Dissolved Solids	K and SO4 better indicators			1997, 1998				
Redox	Results consistent, no longer needed			1998				
NUTRIENTS AND FLUORIDE								
Ammonia (NH3 as N)	Limited areas, correlated w/ NO3	**RETAINED**	**RETAINED**	**NA - routine analyte**				
Nitrate (NO3 as N)	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**	**X**	**X**	**X**	**10**
Orthophosphate (PO4 as P)	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**				
Phosphorous (Total P)	PO4 correlated w/ TP		**RETAINED (8S and SPS)**	1998, 2002	**X**			
Fluoride	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**	**X**	**X**	**X**	**4**
METALS								
Aluminum	Correlated to turbidity not site sources			1998, 2000, 2001				
Antimony	No samples > representative levels			1997, 2000, 2001	**X**		X	0.006
Arsenic	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**	**X**	**X**	**X**	**0.01**
Barium	Sporatic detects > rep levels, highest detects in unimpacted wells			1997, 1998, 2000, 2001, 2002				
Beryllium	No samples > representative levels (except well 318 and once each at wells 311, PEI-3 and PEI-5)			1997	**X**	X	X	0.004
Boron	Detected within the same areas as detects for As and Se [retained] but less frequently than As and Se, no MCL			1998, 2000, 2001, 2002			X	1.36
Cadmium	Sporatic detects > rep levels and at only 2 or 3 wells that are within broader area of impact		**RETAINED**	Added for CERCLA wells 2000, 2001, 2002, 2003	**X**		X	0.005
Chromium	Sporatic detects > rep levels and at only 2 or 3 wells that are within broader area of impact			1997, 1998, 2000, 2001, 2002, 2003	**X (well 318 only)**		X	0.1
Cobalt	Less frequent detects but within same areas as detects for As and Se [retained], no MCL			1997, 1998, 2001				
Copper	Sporatic detects > rep levels			1997, 2000, 2001				
Iron	Correlated to turbidity not site sources			1998				
Lead	No samples > representative levels			1997, 1998, 2000, 2001, 2003		X		
Lithium	Less frequent detects but within same areas as detects for As and Se [retained], no MCL			1998, 2000, 2001, 2002				
Manganese	**RETAINED**			1998, 2001, 2002		X	X	0.077
Mercury	Sporatic detects (less than 3% of results) > rep levels, correlated to volcanic lithology (well 144)			1997, 1998, 2000, 2001	**X**	X	X	0.002
Molybdenum	No samples > representative levels			2000, 2001				
Nickel	Less frequent detects but within same areas as detects for As and Se [retained], no MCL			1997, 1998, 2000, 2001, 2003		X	X	0.1
Selenium	**RETAINED**	**RETAINED**	**RETAINED**	**NA - routine analyte**	**X**	**X**	**X**	**0.05**
Silver	No samples > representative levels			1997, 1998, 2000, 2001, 2003				
Thallium	No samples (except well 318) > representative levels			1997, 2000, 2001	**X**		X	0.002
Vanadium	Less frequent detects but within same areas as detects for As and Se [retained], no MCL			1997, 2000, 2001		X	X	0.108
Zinc	No samples (except well 318) > representative levels			1997, 2000, 2001, 2003		X	X	3.92

TABLE 1. SUMMARY OF FMC'S EVALUATION OF GROUNDWATER CHEMICALS OF CONCERN FROM RI AND POST-RI DATA FROM FMC 100-SERIES AND TW- WELLS, 500-SERIES WELLS AND BATISTE SPRING MONITORING LOCATIONS

Remedial Investigation ANALYTES	Basis for EPA approval to eliminate from CERCLA GW monitoring [a]	Current CERCLA Monitoring [b] ANALYTES	Current RCRA Monitoring [b] ANALYTES	Post-RI "Special" GW Event [c] ANALYTES	EPA 2008 Table [d] "Yellow or Red"	ROD Table 14 GW COPCs	ROD Table 36 GW COCs	ROD GW COCs MCL or RBC [e]
RADIOLOGICAL			EPA agreed to eliminate from RCRA					
Gross alpha	**RETAINED**			1998, 2000, 2001	**X**	X	X	15 PCi/l
Gross beta	Correlated to K-40/K natural ratio			1998, 2000, 2001		X	X	4 mrem/year
Radium-226	83 to 98% samples < MDA			1998, 2000, 2001	**X**	X	X	
Radium-228	75 to 82% samples < MDA			1998, 2000, 2001	**X**	X	X	5 PCi/l combined
Speciated Rad Study			Not in RCRA Monitoring					
Lead-210	No samples detected > MDA						X	Individual radionuclides responsible for gross alpha and gross beta - no MCL or RBCs established for these radionuclides
Polonium-210	No samples detected > MDA					X	X	
Potassium-40	Correlated to K-40/K natural ratio					X	X	
Thorium-230	No samples detected > MDA					X	X	
Thorium-232	No samples detected > MDA							
Uranium 233/234	Correlated to volcanic lithology					X	X	
Uranium 238 (alpha)	Correlated to volcanic lithology					X	X	
ORGANICS								
Volatile Organics	Low level detects of few parameters not temporaly or spatially consistent, probably lab artifacts			1997, 2003, 2005		TCE PCE	TCE PCE	0.005 0.005
Semi-volatile Organics	Low level detects of few parameters not temporaly or spatially consistent, probably lab artifacts			1997, 1998, 2003, 2005				
Non-RI Analytes								
Elemental Phosphorus	No EPA method during RI		**ADDED after 1998 (8S and SPS)**	1998 (Initial sampling/analysis)				0.00073 [h]
Total Cyanide	Not required per RI Workplan			1997, 2000, 2001, 2003				0.2
Cesium-137	Not required per RI Workplan			2000, 2001				
Uranium	Not required per RI Workplan				**X**			0.03

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Remedial Investigation ANALYTES	Number of Results for GW COCs	Average Detection Limit GW COCs [f]	Number of Results > MCL or RBC GW COCs	Percentage Results >MCL or RBC	Wells with Results > MCL or RBC GW COCs	Period of Data > MCL or RBC GW COCs	Period of Data for GW Results Evaluated		Surface Water Comparative Value [g]	Is SurfaceWater Criteria < GW MCL or RBC	Number of Results > Comparative Value	Percent Results > Comparative Value	Selected for 2Q2008 "Special" GW Monitoring
COMMON IONS													
Alkalinity, bicarbonate													No
Calcium													No
Chloride													**Yes (Routine)**
Magnesium													No
Potassium													**Yes (Routine)**
Sodium													No
Sulfate													**Yes (Routine)**
PHYSICAL PARAMETERS													
Spec.Conductivity													**Yes (Routine)**
pH													**Yes (Routine)**
Temperature													**Yes (Routine)**
Total Dissolved Solids													No
Redox													No
NUTRIENTS AND FLUORIDE													
Ammonia (NH3 as N)													**Yes (Routine)**
Nitrate (NO3 as N)	**3,192**	**0.33**	**536**	**16.8%**	**Refer to RI Figure 4.4-22**	**1Q1990 - 2Q2007**	**1Q1990**	**2Q2007**	**0.3 [i]**	**Y**	**2,812**	**88.1%**	**Yes (Routine)**
Orthophosphate (PO4 as P)													**Yes (Routine)**
Phosphorous (Total P)													No
Fluoride	**2,715**	**0.33**	**180**	**6.6%**	**Refer to RI Figure 4.4-24**	**1Q1990 - 2Q2007**	**1Q1990**	**2Q2007**	**7 [j]**	**N**	**NA**	**NA**	**Yes (Routine)**
METALS													
Aluminum													No
Antimony	845	0.0567	12	1.4%	107, 124, 128, 137, 145, 147, 154, 503, 504	2Q1992 - 1Q1995	2Q1992	4Q2001	0.03 [k]	N	NA	NA	**Yes [r]**
Arsenic	**3,875**	**0.0078**	**2,619**	**67.6%**	**Refer to RI Figure 4.4-14**	**1Q1990 - 2Q2007**	**1Q1990**	**2Q2007**	**0.15 [l]**	**N**	**NA**	**NA**	**Yes (Routine)**
Barium													No
Beryllium	765	0.0011	0	0.0%	None	NA	4Q1990	4Q1997	0.00053 [m]	Y	11	1.4%	No
Boron	875	0.2203	161	18.4%	150, 152, 155, 156, 157, 115, 131, 132, 168, 104, 159, 114, 143, 140, 141, 116, 134	3Q1992 - 4Q2001	3Q1992	4Q2001	0.0016 [n]	Y	707	80.8%	**Yes [s]**
Cadmium	3,063	0.0012	10	0.3%	136, 143, 151, TW-12S	2Q1992 - 4Q1997	4Q1990	2Q2007	0.00046 [o]	Y	60	2.0%	**Yes (Routine RCRA only)**
Chromium	1,229	0.0046	2	0.2%	158	3Q1993	4Q1990	2Q2003	0.16 [o]	N	NA	NA	No
Cobalt													No
Copper													No
Iron													No
Lead													No
Lithium													No
Manganese	1,334	0.0043	546	40.9%	Refer to RI Figure 4.4-19	4Q1990 - 2Q2002	4Q1990	2Q2002	No CV	NA	NA	NA	**Yes [s]**
Mercury	922	0.0002	11	1.2%	121, 144 (8 of 11 results > MCL), TW-2S, TW-5S, 506	3Q1991 - 3Q1994	1Q1991	4Q2001	0.00077 [l]	Y	21	2.3%	No
Molybdenum													No
Nickel	871	0.0154	0	0.0%	None	NA	4Q1990	2Q2003	0.11 [o]	N	NA	NA	No
Selenium	**3,835**	**0.0070**	**186**	**4.9%**	**Refer to RI Figure 4.4-20**	**4Q1990 - 2Q2007**	**4Q1990**	**2Q2007**	**0.005 [l]**	**Y**	**1106**	**28.8%**	**Yes (Routine)**
Silver													No
Thallium	845	0.0037	16	1.9%	108, 121, 123, 131, 135, 139, 147, 150, 152, 156, 510	2Q1992 - 3Q2000	2Q1992	4Q2001	0.004 [m]	N	NA	NA	No
Vanadium	1,139	0.0167	33	2.9%	123 (25 of 33 results > RBC), 143, TW-2I, TW-2S, TW-9S	4Q1990 - 4Q2001 (Well 123) 2Q1991-4Q1997 (other wells)	4Q1990	4Q2001	0.012 [m]	Y	192	16.9%	**Yes [t]**
Zinc	1,159	0.0210	0	0.0%	None	NA	4Q1990	2Q2003	0.26 [o]	Y	0	0%	No

TABLE 1. SUMMARY OF FMC'S EVALUATION OF GROUNDWATER CHEMICALS OF CONCERN FROM RI AND POST-RI DATA FROM FMC 100-SERIES AND TW- WELLS, 500-SERIES WELLS AND BATISTE SPRING MONITORING LOCATIONS

Remedial Investigation ANALYTES	Number of Results for GW COCs	Average Detection Limit GW COCs [f]	Number of Results > MCL or RBC GW COCs	Percentage Results >MCL or RBC	Wells with Results > MCL or RBC GW COCs	Period of Data > MCL or RBC GW COCs	Period of Data for GW Results Evaluated	Surface Water Comparative Value [g]	Is SurfaceWater Criteria < GW MCL or RBC	Number of Results > Comparative Value	Percent Results > Comparative Value	Selected for 2Q2008 "Special" GW Monitoring
RADIOLOGICAL												
Gross alpha	816		27	3.3%	110, 111, 108, 117, 122, 140, 150, 152, 142, 146, 161, TW-12S, 515, 521	2Q1992 - 4Q1994	1Q1990 3Q2000	No CV	NA	NA	NA	**Yes [u]**
Gross beta	765		0	0.0%		NA	1Q1990 3Q2000	No CV	NA	NA	NA	No
Radium-226	622		32	5.1%	TW-10S, 128, 119, 144, 122, 110, 146, TW-12S, 154, 102, 127, TW-3D, 135, 139, 103, 112, 159, 107, 116, 118, 106, TW-11I, 136, 508, 511, 513, 517, Batiste Spring	3Q1992 - 1Q1994	3Q1992 3Q2000	No CV	NA	NA	NA	**Yes**
Radium-228	623							No CV	NA	NA	NA	**Yes [s]**
Speciated Rad Study												
Lead-210								NA	NA	NA	NA	No
Polonium-210								NA	NA	NA	NA	No
Potassium-40								NA	NA	NA	NA	No
Thorium-230								NA	NA	NA	NA	No
Thorium-232								NA	NA	NA	NA	No
Uranium 233/234								NA	NA	NA	NA	No
Uranium 238 (alpha)								NA	NA	NA	NA	No
ORGANICS												
Volatile Organics	TCE 127	0.0048	5	3.9%	121	3Q1992 - 2Q1993	3Q1992 2Q2005	0.047 [p]	N	NA	NA	No
	PCE 127	0.0048	1	0.8%	111 (3Q1992 sample only)	3Q1992	3Q1992 2Q2005	0.045 [p]	N	NA	NA	No
Semi-volatile Organics												No
Non-RI Analytes												
Elemental Phosphorus	236	0.0004	36	15.3%	108, 122, 123 (4Q2003 only)	1Q1998 - 2Q2007	1Q1998 2Q2007	0.0001 [n]	Y	NC [q]	NC	**Yes [v]**
Total Cyanide	51	0.01	4	7.8%	131, 168	3Q2000 - 4Q2001	4Q1997 2Q2003	0.0052 [l]	Y	NC	NC	**Yes [v]**
Cesium-137												No
Uranium	0	NA	NA	NC				0.0026 [k]	Y	NC	NC	**Yes [w]**

NOTES:
[a] Details are provided in the Remedial Investigation Report for the Eastern Michaud Flats Site, Bechtel Environmental, Inc., [Final RI Report] August 1996.
[b] Current FMC groundwater monitoring program analytical lists as of 4th quarter 2007.
[c] The FMC special groundwater monitoring events are detailed in “Summary of FMC’S Post-Remedial Investigation (1995-2007) Groundwater Monitoring Programs and Supplemental Groundwater Sampling and Analysis Events,” February 2008.
[d] File entitled "mls-GW-Screen with Eco.xls," "GW Screen Alpha" worksheet, dated 2/6/08 attached to K. Lynch, EPA electronic message dated 2/6/2008, subject: Fw: GW table w/ eco benchmarks.
[e] EMF ROD Maximum Contaminant Level (MCL) or Risk-Based Concentration (RBC) from ROD Table 36, except Arsenic MCL is current 2008 MCL. All values in mg/l except as otherwise indicated.
[f] All values in mg/l except as otherwise indicated.
[g] All values in mg/l except as otherwise indicated, see additional notes for source of comparative value.
[h] 2004 EPA Region IX Preliminary Remediation Goal (PRG) for tap water.
[i] Value is IDEQ Portnuef River TMDL target for Total inorganic Nitrogen.
[j] Value is derived from Camargo fluoride paper, provided to FMC by EPA at the EMF meetings on February 12 and 13, 2008, and assuming the average water hardness at Batiste Spring of 250 mg/L.
[k] Tier II Secondary Chronic Value (SCV) surface water screening benchmark from Oak Ridge National Laboratory's Risk Assessment Information System (RAIS).
[l] EPA National Ambient Water Quality Criteria CCC.
[m] EPA Region IV chronic surface water screening benchmark from RAIS.
[n] EPA Region VI freshwater screening benchmark from RAIS.
[o] EPA National Ambient Water Quality Criteria CCC for hardness-dependent parameter calculated for Batiste Spring average hardness of 250 mg/l.
[p] EPA Region V Ecological Screening Level (ESL) for surface water from RAIS.
[q] NC means Not Calculated
[r] Selected due to COC detection limit not routinely less than MCL or RBC.
[s] Selected due to COC detected greater than MCL or RBC in greater than 5-percent of results.
[t] Selected due to COC detected greater than surface water CV in greater than 5-percent of results.
[u] Gross alpha selected to supplement the database for wells upgradient and downgradient from the FMC Plant OU.
[v] Selected because the groundwater parameter was not analyzed during the RI and has been subsequently detected above its comparative value in groundwater at the FMC Plant OU.
[w] Selected because no groundwater data is available for total uranium for the FMC Plant OU and downgradient wells.

Addendum (April 2008)
Table 3-4a
Groundwater Sampling Locations 2Q2008 Event

Location	Well Numbers [a]
FMC Facility	101, 102, 108, 110, 111, 112, 122, 123, 127, 134, 136, 139, 143, 145, 146, 147, 149, 156, 161, 164, 167, 169, 173, 174, 175, 183, 189
Outside FMC Facility Boundary	501, 502, 515, 516, 517, 523, 524, 525, TW-9S, TW-11S, TW-12S
Batiste Spring	Batiste Spring

[a] Elemental phosphorus will be included as a 2Q2008 special event analyte for the following wells: 110, 111, 146, TW-9S, 502, 517, TW-11S, TW-12S, and Batiste Spring.

Follows A-16

Addendum (April 2008)
Table 3-5a
Summary of Groundwater Sampling and Analyses for 2Q2008 Event

Type of Analysis	Number of Primary Analyses [a, b]
Field Analyses	
pH	39
Temperature	39
Specific Conductance	39
Turbidity	39
Dissolved Oxygen	39
ORP	39
Laboratory Radiological Analyses	
Gross Alpha	39 [c]
Radium-226	39 [c]
Radium-228	39 [c]
Laboratory Chemical Analyses	
Metals	39 [c]
Water Quality Parameters	39 [c]
Total Cyanide	39 [c]
Elemental Phosphorus	9 [c, d]
Total Uranium	39 [c]

[a] Number of primary analyses, QC samples not included.

[b] Field QC samples will be collected at a rate of 1 per 20 primary samples or 1 per sample delivery group (SDG) whichever number of primary samples is less.

[c] Field QC samples to be collected include duplicate, MS/MSD and rinseate blank samples.

[d] Elemental phosphorus will be included as a 2Q2008 special event analyte for the following wells: 110, 111, 146, TW-9S, 502, 517, TW-11S, TW-12S, and Batiste Spring.

Follows A-17

Addendum (April 2008)
Table 5-1a, III. GROUNDWATER
Analytical Methods for 2Q2008 Groundwater Monitoring Event

Parameter	Method	Detection Limit	Units
Routine Analytes			
General WQP			
Ammonia	EPA 350.3	0.2	mg/l
Chloride	EPA 300.0	1	mg/l
Fluoride	EPA 300.0	0.1	mg/l
Nitrate	EPA 300.0	0.1	mg/l
Total Phosphorus	SW6020	0.019	mg/l
Sulfate	EPA 300.0	1	mg/l
Metals			
Arsenic	SW6020	0.0019	mg/l
Cadmium (RCRA wells only)	SW6020	0.0005	mg/l
Potassium	SW6020	0.1	mg/l
Selenium	SW6020	0.00048	mg/l
2Q2008 Special Parameters			
Metals			
Antimony	SW6020	0.00068	mg/l
Boron	SW6020	0.018	mg/l
Manganese	SW6020	0.0006	mg/l
Mercury	SW7470A	0.0002	mg/l
Vanadium	SW6020	0.0021	mg/l
Radionuclides			
Gross alpha	EPA 900	3	pCi/l
Radium 226	EPA 903	1	pCi/l
Radium 228	EPA 904 mod	1	pCi/l
OTHER			
Total Cyanide	EPA 335.4	0.01	mg/l
Total Uranium	SW6020	0.001	mg/l
Elemental Phosphorus	SW7580	0.00008	mg/l

Follows Page A-36

Addendum (April 2008)
Table 5-5a, III. GROUNDWATER

Analytical Parameters for 2Q2008 Groundwater Monitoring Event

Parameter
Routine Analytes
General WQP
Ammonia
Chloride
Fluoride
Nitrate
Total Phosphorus
Sulfate
Metals
Arsenic
Cadmium (RCRA wells only)
Potassium
Selenium
2Q2008 Special Parameters
Metals
Antimony
Boron
Manganese
Mercury
Vanadium
Radionuclides
Gross alpha
Radium 226
Radium 228
OTHER
Total Cyanide
Total Uranium
Elemental Phosphorus [a]

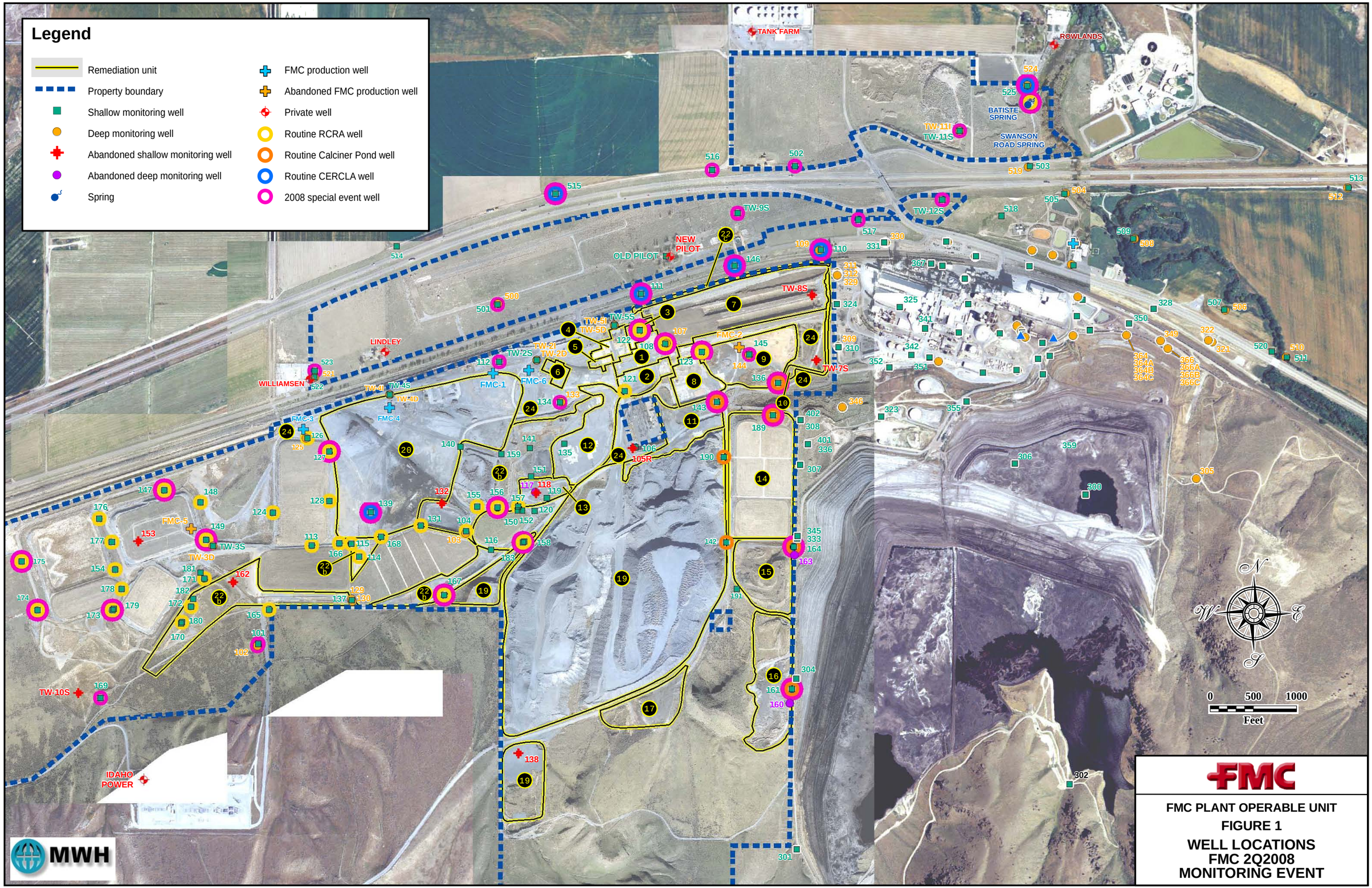
[a] Elemental phosphorus will be included as a 2Q2008 special event analyte for the following wells: 110, 111, 146, TW-9S, 502, 517, TW-11S, TW-12S, and Batiste Spring.

Follows Page A-43

Addendum (April 2008)
Table 7-1a, III. GROUNDWATER
Sample Containers, Preservatives and Holding Times for 2Q2008 Groundwater Monitoring Event

Parameter	Container	Preservative	Holding Time
Routine Analytes			
General WQP			
Ammonia	Polyethylene	H2SO4 to pH < 2; cool to 4°C	28 days
Chloride	Polyethylene	None	28 days
Fluoride	Polyethylene	None	28 days
Nitrate	Polyethylene	Cool to 4°C	48 hours
Total Phosphorus	Polyethylene	HNO3 to pH < 2; cool to 4°C	28 days
Sulfate	Polyethylene	Cool to 4°C	28 days
Metals			
Arsenic	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Cadmium (RCRA wells only)	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Potassium	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Selenium	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
2Q2008 Special Parameters			
Metals			
Antimony	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Boron	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Manganese	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Mercury	Polyethylene	HNO3 to pH < 2; cool to 4°C	28 days
Vanadium	Polyethylene	HNO3 to pH < 2; cool to 4°C	6 months
Radionuclides			
Gross alpha	Polyethylene	HNO3 to pH < 2	6 months
Radium 226	Polyethylene	HNO3 to pH < 2	6 months
Radium 228	Polyethylene	HNO3 to pH < 2	6 months
OTHER			
Total Cyanide	Polyethylene	NaOH to pH > 12; cool to 4°C	14 days
Total Uranium	Polyethylene	HNO3 to pH < 2	6 months
Elemental Phosphorus	Amber glass, PTFE-lined cap	Cool to 4°C	Extracted: 5 days Analyzed: 30 days

Follows Page A-20



FILE Fig 1_FMC_WellLocations_2008Monitoring_3_27_08.mxd 3/28/08

ATTACHMENT A

INTERIM CERCLA GROUNDWATER MONITORING

FIELD SAMPLING PLAN

INTERIM CERCLA GROUNDWATER MONITORING FIELD SAMPLING PLAN

Prepared for:

FMC Idaho, LLC

Pocatello, Idaho

July 2010

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INTERIM CERCLA GROUNDWATER MONITORING FIELD SAMPLING PLAN

1.0 INTRODUCTION

1.1 BACKGROUND

This Field Sampling Plan (FSP) provides sampling and analysis procedures for groundwater samples collected under the Interim CERCLA Groundwater Monitoring Program at the FMC Idaho, LLC (FMC) property in Pocatello, Idaho. The FSP has been prepared as Attachment A to the Interim CERCLA Groundwater Monitoring Plan (GMP).

The FSP contains procedures for sample collection, labeling, storage, shipment, chain-of-custody protocols, and quality assurance/quality control (QA/QC). The plan also specifies the analytical parameters, test methods, and threshold concentrations. Implementation of these procedures will also ensure that sampling equipment and supplies have been properly decontaminated.

1.2 PREVIOUS RESULTS

In accordance with the Eastern Michaud Flats Superfund Site remedial investigation and FMC's subsequent voluntary CERCLA groundwater quality monitoring program, the monitoring wells associated with this monitoring program have been sampled at a quarterly to semi-annual frequency over a period of up to 17 years. A summary of the groundwater quality, primarily based on average results from 2006 to 2008, at the interim CERCLA program wells is presented in Table A-1. Additional review of recent groundwater quality data is presented in Section 2.2 of the GMP. A detailed description of groundwater quality at the site is presented in the Groundwater Current Conditions Report (GWCCR) for the FMC Plant OU (FMC, June 2009).

TABLE A-1. SUMMARY OF GROUNDWATER QUALITY AT THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM WELLS

Parameters	**134**	**139**	**145**	**151**	**159**	**110**	**111**	**146**	**523**
Field Measurements									
pH (Field)	6.73	6.92	5.44	7.1	6.87	6.86	7.1	7.11	7.38
SC (UMHOS/CM)	2805	4643	5600	1250	2180	1429	1513	1294	893
Turbidity (NTU)	1.2	0.45	4.5	0.5	.9	0.4	0.5	0.35	0.2
Water Temperature (°C)	16.9	12.8	15.3	16.3	16.8	17.1	14.8	16.9	13.4
General WQP (mg/L)									
Potassium	153	38.5	37.7	57.4	36.9	25.4	49.5	46.3	8.49
Sulfate	325	1051	2400	177	166	215	157	128	59.6
Chloride	287	886	154	114	210	89.8	170	132	108
Fluoride	0.2	0.583	0.5	NA	NA	0.435	0.105	0.378	0.5
Ammonia	0.5	0.175	2.5	<0.2	1.9	0.15	0.15	0.15	0.2
Nitrate	21.2	35.5	4.5	0.41	<0.1	3.8	8.98	6.13	4.5
Orthophosphate/ Total P	19.80	0.74	57.3	7.6	14.1	3.09	3.95	1.33	0.30
Metals (mg/L)									
Arsenic	0.098	0.039	0.298	0.031	0.093	0.048	0.024	0.029	0.004
Selenium	0.05	0.038	0.061	<0.005	<0.005	0.029	0.005	0.003	0.003

NA means parameter not analyzed.

Results are average for four sampling events (4Q06 to 2Q08) except the results for well 145 are from May 2008 and 151 and 159 are from November 2001 due to the lack of sufficient data points to calculate a current average value for these wells..

Non-detect results were included as equal to the detection limit for calculation of averages.

TABLE A-1 (CONTINUED). SUMMARY OF GROUNDWATER QUALITY AT THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM WELLS

Parameters	TW-9S	502	517	TW-12S	515	TW-11S	524	525
Field Measurements								
pH (Field)	7.06	7.28	6.93	6.5	7.37	7.18	7.55	7.52
SC (UMHOS/CM)	1842	1036	2575	1125	1260	845	517	524
Turbidity (NTU)	8	0.2	0.3	8.5	0.475	9.5	0.325	0.35
Water Temperature (°C)	14.4	12.6	15.9	14.4	13.3	12.4	12.4	12.1
General WQP (mg/L)								
Potassium	58.4	5.4	100	15.7	8.85	3.8	4.21	4.15
Sulfate	161	64.9	189	132	132	49.7	42.9	44.6
Chloride	187	44.3	198	46.2	197	19.9	18.5	19.2
Fluoride	0.1	0.9	0.6	1.1	0.683	0.8	0.675	0.718
Ammonia	0.2	>0.2	0.2	0.7	0.15	<0.2	0.15	0.133
Nitrate	9.95	1.6	11.1	6.1	2.75	1.6	1.88	1.95
Orthophosphate/ Total P	3.21	<0.5	0.92	16.90	0.20	<0.5	0.20	0.25
Metals (mg/L)								
Arsenic	0.027	0.003	0.047	0.017	0.005	0.002	0.004	0.006
Selenium	0.005	>0.005	0.014	0.006	0.003	<0.005	0.005	0.005

Results are average for four sampling events (4Q06 to 2Q08) except for wells 502, 517 and TW-11S that are results for May 2008 only due to the lack of sufficient data points to calculate a current average value for these wells.

Non-detect results were included as equal to the detection limit for calculation of averages.

2.0 SAMPLING OBJECTIVES

The objectives of sampling monitoring wells associated with the Interim CERCLA Groundwater Monitoring Program are to:

- Collect samples representative of groundwater flowing beneath the FMC Plant OU.
- Generate data (field measurements and laboratory analytical results) that meets data quality objectives.
- In conjunction with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs, evaluate potential changes and/or trends in groundwater conditions on an OU-wide basis.

3.0 SAMPLING LOCATIONS AND FREQUENCY

The interim CERCLA program monitoring well locations are shown in Figure A-1. Table A-2 presents a summary of well construction details. Well construction logs appear in Appendix A-A of this FSP.

3.1 GROUNDWATER MONITORING WELL SAMPLES

Groundwater monitoring well samples will be collected semi-annually from each of the interim CERCLA program wells in accordance with the procedures specified in Section 5. Consistent with prior practice, the semi-annual CERCLA groundwater monitoring events will typically be performed during May and November each year. All of these wells will typically be sampled within a one week period during each sampling event. Each sample will then be submitted to the laboratory in accordance with the procedures specified in Section 6. As described in the GMP and specified in Section 6, in addition to the routine semi-annual groundwater monitoring events, groundwater monitoring for an expanded laboratory parameter list will be performed every five years during the second quarter monitoring event, beginning with the second quarter 2012 [2Q12] monitoring event.

3.2 FIELD DUPLICATE GROUNDWATER MONITORING WELL SAMPLES

Field duplicate groundwater samples will be collected at a frequency of one per sample delivery group or one per twenty samples collected. The well designated for a field duplicate sample will be randomly selected during each monitoring event from one of the sixteen interim CERCLA program monitoring wells.

3.3 MATRIX SPIKE / MATRIX SPIKE DUPLICATE QUALITY CONTROL SAMPLES

Matrix spike / matrix spike duplicate (MS/MSD) quality control samples will also be collected at a frequency of one per sample delivery group or one per twenty samples collected. The well designated for a MS/MSD quality control sample will be randomly selected during each monitoring event from one of the sixteen interim CERCLA program monitoring wells.

3.4 FIELD BLANK QUALITY CONTROL SAMPLES

During each CERCLA monitoring event, field blank samples will be collected as follows:

Rinsate blank - Rinsate blanks are collected by pumping purified (distilled or deionized) water through the submersible pump setup to evaluate the effectiveness of field decontamination of sampling equipment. The blank is analyzed for the same analytical parameters as the groundwater samples. Rinsate blanks will be collected after decontamination and at a minimum frequency of one per sample delivery group or one per twenty samples collected.

Distilled or De-ionized water blank – Distilled or de-ionized water blanks are aliquots of water collected directly from the field supply container and analyzed to determine distilled or de-ionized water quality. The blanks are collected at a frequency of one per sampling event in

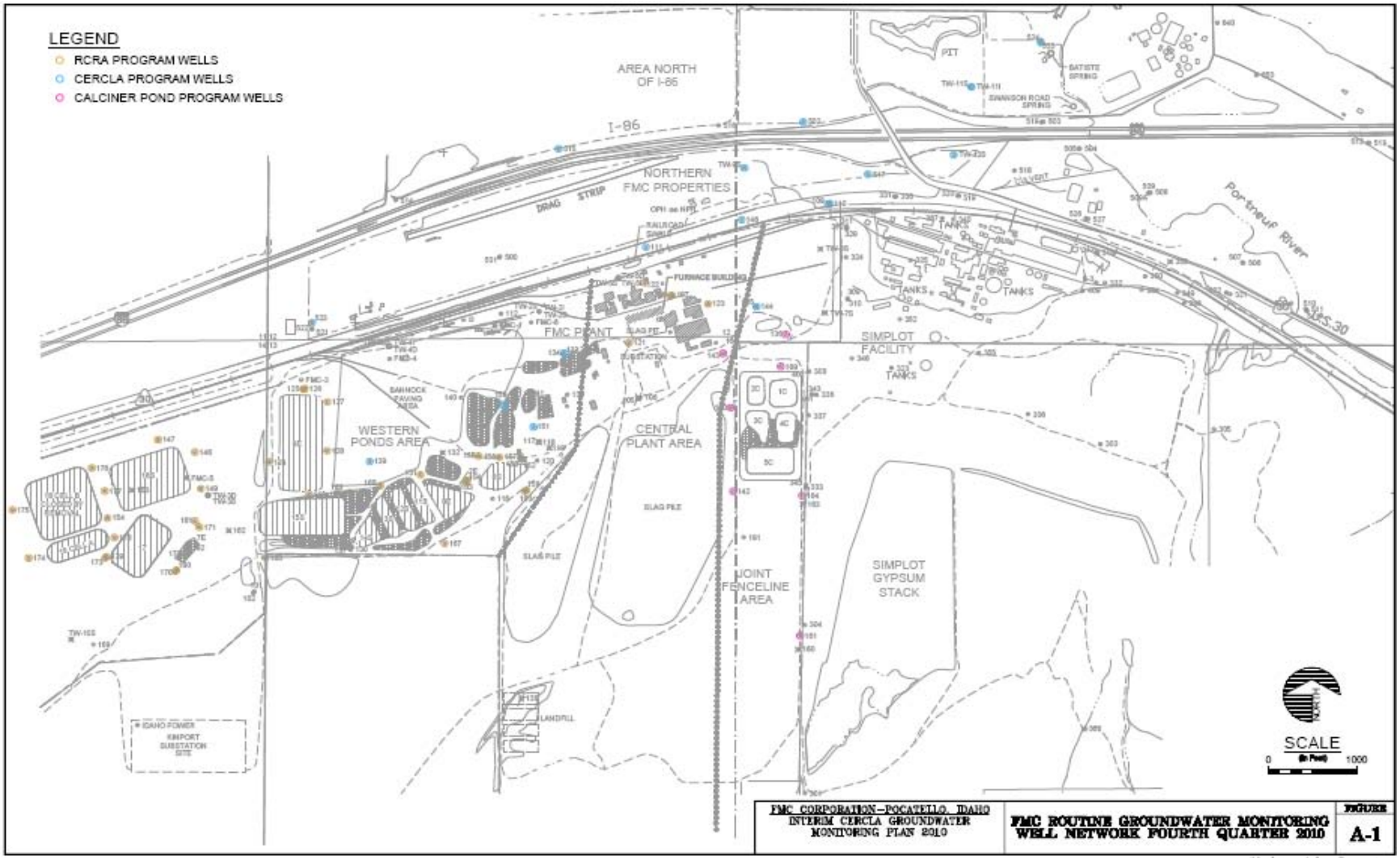
conjunction with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs (i.e., one distilled or de-ionized water blank per sampling event concurrently satisfies requirement for all three monitoring programs).

TABLE A-2. WELL CONSTRUCTION SUMMARY AND MAY 2008 WATER LEVELS

WELL	Easting	Northing	"Top of Casing" Measuring Point Elevation *	Top of Screen Elevation*	Bottom of Screen Elevation*	Well Bottom Elevation*	Borehole Total Depth Elevation*	Depth to Water May 2008	Water Elevation May 2008
110	558378.9	453398.7	4450.57	4364.30	4354.30	4351.80	4347.80	66.27	4384.30
111	556296.9	452890.2	4468.04	4374.00	4364.60	4361.80	4356.30	76.37	4391.67
134	555354.2	451636.8	4478.93	4374.50	4365.00	4362.20	4361.00	85.18	4393.75
139	553167	450368.1	4467.66	4377.90	4373.70	4370.30	4303.30	72.90	4394.76
145	557552.3	452188.7	4478.26	4347.00	4337.00	4334.50	4327.00	86.97	4391.29
146	557382.2	453214.1	4459.30	4367.90	4352.90	4350.40	4349.40	70.24	4389.06
151	555023.3	450773.5	4501.42	4374.90	4364.90	4362.40	4361.90	107.04	4394.38
159	554680.1	451036	4491.79	4381.30	4371.30	4368.30	4364.00	97.30	4394.49
502	558079.5	454363.3	4441.30	4375.10	4370.10	4367.30	4365.30	57.06	4384.24
515	555307.3	454045.1	4450.35	4379.10	4369.10	4366.10	4364.30	58.32	4392.03
517	558812.8	453747	4444.45	4377.10	4367.10	4364.10	4363.00	60.34	4384.11
523	552513.7	452001.4	4452.98	4375.80	4365.80	4365.30	4360.80	58.46	4394.52
524	560768	455307	4399.92	4348.90	4338.90	4338.40	4275.40	17.06	4382.86
525	560772.1	455296.9	4399.61	4379.30	4369.30	4368.80	4368.60	16.72	4382.89
TW-11S	559985	454775	4426.24	4377.00	4367.00	4367.00	4367.00	42.37	4383.87
TW-12S	559785	453975	4436.28	4381.00	4373.00	4373.00	4373.00	52.19	4384.09
TW-9S	557413.1	453819.7	4450.23	4373.00	4369.00	4369.00	4269.00	64.90	4385.33

* - Elevations are in Feet Above Mean Sea Level

FIGURE A-1. GROUNDWATER MONITORING WELL LOCATION MAP AND ROUTINE GROUNDWATER MONITORING WELL NETWORKS



4.0 SAMPLE DESIGNATION

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The samples will have pre-assigned, identifiable, and unique ID numbers. At a minimum, the sample labels will contain the following information:

- Facility name.
- Sample number.
- Date of collection.
- Time of collection.
- Analytical parameter.
- Method of preservation.

Each sample will be assigned a unique sample number. The same unique number will be used to identify all containers associated with that sample. The sample coding convention used for the Interim CERCLA monitoring program (which is also consistent with the RCRA, and Calciner Pond Remedial Action groundwater programs sample coding) is described in Section 5.1.1 below.

5.0 SAMPLING EQUIPMENT AND PROCEDURES

This section describes the procedures to be used to collect groundwater samples. All samples will be collected in accordance with the procedures presented in this section and handled in accordance with the procedures presented in Section 6.

5.1 FIELD LOGBOOKS

Field logbooks will document where, when, how, and from whom any vital project information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. At a minimum, the following sampling information will be recorded:

- Sample location, station location, and description.
- Sample number.
- Sampler's name(s).
- Date and time of sample collection.
- Type of sample (e.g., regular, QA sample designation).
- Type of sampling equipment used.
- Onsite measurement data (e.g. temperature, pH, conductivity).
- Field observations and details important to analysis or integrity of samples (e.g., heavy rains, odors, colors).
- Type of preservation used.

In addition, the following will be kept in a Field Data Report:

- Chain-of-custody forms.
- Shipping arrangements (i.e., Federal Express air bill number).
- Recipient laboratory(ies).

5.1.1 Sample Coding in Field Logbooks

The station location will be described in the logbook as follows, in a manner consistent with the conventions used during the remedial investigation.

A one-digit number will be used to indicate the year in which the sample was collected, for example “3” indicates a sample was collected in 2003. This digit will be followed by two others indicating the month in which the sample was collected, for example “11” indicates a sample was collected in November. Finally, additional digits or letters will identify the well from which the sample was collected. The location description, 311136, indicates a sample collected from Well 136 in November 2003.

Samples collected for field QC will be identified by a three-digit or descriptive letter combination. Numbers for well locations and field QC will be grouped as follows:

- CERCLA Groundwater Monitoring Wells: 100, TW and 500 series numbers.
- Field Duplicate: 600 series starting with 600 for each sampling event and continuing consecutively during the event for duplicates collected.
- Rinsate: 700 series numbers starting with 700 for each sampling event and continuing consecutively during the event for rinsates collected.
- Distilled/deionized water blank: FDI.

Samples collected for laboratory QC will be identified on bottles and field paperwork using an A, B, or C designation as a suffix to the sample identifier code. These QC codes will be designated as follows:

- A - Original unspiked sample
- B - Matrix spike
- C - Matrix spike duplicate

The date of collection will be indicated in mm/dd/yy format, and the time will be indicated in accordance with the military convention. The analytical parameter and method of preservation will be indicated in unambiguous shorthand, such as K for potassium and HCl for hydrochloric acid.

Logbooks will be bound with consecutively numbered pages. Each page will be dated and the time of entry noted in military time. All entries will be legible, written in ink, and signed by the individual making the entries. Language will be factual, objective, and free of personal opinions or inappropriate terminology. In addition to the sampling information, the following specifics will also be recorded in the field logbook:

- Team members.
- Time of site arrival/entry on site and time of site departure.
- Other personnel on site.
- Any deviations from sampling plans, site safety plans, and QAPP procedures.
- Any changes in personnel and responsibilities as well as reasons for the changes.
- Equipment calibration and equipment model and serial number.

5.2 GROUNDWATER MONITORING WELL SAMPLE COLLECTION

5.2.1 Water Level Measurements

FMC performs quarterly groundwater level (elevation) measurements at numerous monitoring wells that provide uniform coverage across the entire FMC Plant OU such that the water level measurements are coordinated among FMC's RCRA, Calciner Pond Remedial Action and interim CERCLA groundwater monitoring programs. Routine quarterly water level measurements will be taken at the following list of wells:

- Wells 101 through 191 inclusive (i.e., includes all shallow and deep wells within the FMC "100-series" wells);
- TW-5S, TW-5I, TW-5D, TW-9S, TW-11S and TW-12S; and,
- 501, 502, 503, 505, 514, 515, 516, 517, 518, 523, 524 and 525.
- In addition, the surface water elevation will be measured in the Batiste Spring channel immediately below the overflow weir from the springhouse cistern and in the Swanson Road Spring (aka the Spring at Batiste Road) basin.

The coordinates and elevation above mean sea level of the measuring points for monitoring well (groundwater) and spring (surface water) water level measurements are listed on the table in Appendix A-B.

Water levels will be established, generally in a single day, prior to purging and sampling the wells. Wells will be purged and sampled on subsequent days within the sampling event. An electronic sounder, accurate to the nearest (+/–) 0.01 feet, will be used to measure depth to water in each well. When using an electronic sounder, the probe is lowered down the casing to the top of the water column. The graduated markings on the probe wire are used to measure the depth to water from the surveyed point on the rim of the well casing. Typically, the measuring device emits a constant tone when the probe is submerged in standing water, and most electronic water level sounders have a visual indicator consisting of a small light bulb or diode that turns on when

the probe encounters water. Water level sounding equipment will be decontaminated by rinsing with de-ionized or distilled water before and after use in each well.

The long-history of groundwater monitoring indicates that there is no significant sediment entering the groundwater monitoring wells. Consequently, it is unnecessary to measure total well depth on a routine basis. However, FMC's groundwater sampling contractor will measure total well depth at any wells that, based on the sampling contractors experience and historic monitoring of the wells, are suspected to have significant (e.g., above the screened interval) sediment accumulation. In the event significant sediment accumulation is found based on measured total depth compared to the well construction details for the well, the groundwater sampling contractor will notify FMC. FMC will determine whether the well will be sampled prior to or after actions to remove the excessive sediment (e.g., well redevelopment).

5.2.2 Well Purging

All wells will be purged prior to sampling. Three to five casing volumes of water will be purged using an electric submersible pump. Clean flexible plastic or Teflon tubes connected to pumps will be used for groundwater extraction. All tubes will be decontaminated before and after use in each well. Pumps will typically be placed approximately 10 feet below the water level in the well to permit reasonable drawdown but to prevent cascading conditions. Pumps may need to be placed lower in the water column at certain wells to avoid lowering the water level to the pump inlet horizon due to the poor yield characteristics of these monitoring wells. If necessary, purge water will be collected into a measured container to record the purge volume.

Casing volumes will be calculated based on total well depth and static water level; casing diameter will be based on the well construction details. Monitoring well construction details are summarized in Table A-2 along with water elevations measured during May 2008.
One casing volume will be calculated as:

$$V = \pi R^2 h / 19.25$$

where:

V is the volume of one well casing of water (in gallons, 1 gallon = 0.134 ft^3);

R is one-half the inner diameter of the well casing (in inches); and

h is the total depth of water in the well (in feet).

Prior to the start of sampling and after each well casing volume is purged, water temperature, pH, specific conductance, dissolved oxygen (DO) and oxidation-reduction potential (ORP) will be measured using in-line flow-through meters installed in a manifold off the pump system. A separate grab sample will be obtained to measure turbidity the same time interval as other field parameters. The flow-through cell and associated tubing will be emptied prior to sampling a subsequent well. During operation, the flow-through cell and tubing are flushed with purge water at approximately one gpm for five to ten minutes before field parameters are recorded. This flushing action and the non-absorptive nature of this sampling equipment makes it unnecessary to otherwise decontaminate the tubing and in-line meters between uses using the

equipment decontamination methods presented in Section 5.6 of this FSP. The tubing and in-line flow-through meter system will not be used to collect regular groundwater sample that are analyzed for the parameters listed in Table 3-2 of the GMP. The final measurements will be recorded after these parameters have stabilized, indicating representative formation water is entering the well.

Three consecutive measurements which display consistent values of all parameters will be taken prior to sampling. Samples will be collected after three well casing volumes if parameters have stabilized. Typically, the temperature should not vary by more than (+/–)1°C, pH by more than 0.1 pH units, DO by no more than 0.3 mg/L and specific conductance by more than 10 percent from reading to reading. No water that has been tested with a field meter probe will be collected for chemical analysis. If these parameters have not stabilized after five casing volumes have been purged, purging will cease, a notation will be recorded in the field logbook, and samples will be collected. In accordance with Section 5.1, depth-to-water measurements, field measurements of parameters, and purge volumes will be recorded in the field logbook. The in-line flow meter used to estimate the volume of removed purged water will be field-checked for volumetric accuracy once during a sampling event by recording the time needed to obtain a known volume of purge water in a bucket.

If a monitoring well dewaters during purging and three casing volumes are not purged, that well will be allowed to recharge up to 80 percent of static water column, and dewatered once more. After water levels have recharged to 80 percent of the static water column, groundwater samples will be collected.

All field meters will be calibrated according to manufacturers' guidelines and specifications prior to beginning field work every day.

5.2.3 Well Sampling

Groundwater samples will be collected from the interim CERCLA monitoring wells specified in Table A-3 and illustrated in Figure A-1. Prior to sampling, the water level in the well will be measured as described in Section 5.2.1 and wells will be purged as described in Section 5.2.2. All wells will be sampled within 24 hours after purging. Clean nitrile or latex gloves will be worn while collecting samples. Groundwater samples will be collected directly from the pump tubing into the appropriate sample container, preserved as described in Section 6, and chilled and processed for shipment to the laboratory. When transferring samples, care will be taken not to touch the discharge tubing to the sample container.

Section 6 gives detailed procedures for sample packaging, labeling, and shipping. All groundwater sampling equipment will be decontaminated before and after each sample is collected using procedures outlined in Section 5.6.

TABLE A-3. FMC'S ROUTINE GROUNDWATER MONITORING PROGRAM WELL NETWORKS (4Q 2010)

Area	Well Numbers	Up / Downgradient	Program [1]
Pond 18 Cell A	174	U	RCRA
	154, 177, 178	D	RCRA
Pond 17	173	U	RCRA
	171, 172, 180	D	RCRA
Pond 16S	154	U	RCRA
	147,148, 149	D	RCRA
Pond 15S	165	U	RCRA
	113, 115, 166	D	RCRA
Phase IV ponds	167	U	RCRA
	104, 114, 131, 168	D	RCRA
Pond 9E	124, 113	U	RCRA
	126, 127, 128	D	RCRA
Pond 8E	167	U	RCRA
	104, 114, 131, 168	D	RCRA
Pond 8S	158, 183	U	RCRA
	155, 156, 157	D	RCRA
Slag Pit Sump	121	U	RCRA
	108, 122, 123	D	RCRA
Batiste Spring	Batiste Spring	D	RCRA
Calciner Ponds	164, 161, 142	U	IDEQ
	136, 143, 189, 190	D	IDEQ
On-Plant Site	134, 139, 151, 159, 145	D	CERCLA
Downgradient from Plant Site	111, 146, 110, TW-9S	D	CERCLA
Downgradient from FMC and Simplot Plant Sites	517, TW-12S	D	CERCLA
Northern Perimeter of EMF Groundwater Impact [2]	523, 515, 502, TW-11S, 524, 525	Cross	CERCLA

Note: This table only includes the monitoring well networks for sampling and analysis. The list of wells designated for water level monitoring is presented in Section 3.1 of the ICGMP and 5.2.1 of this FSP.
[1] Program: RCRA = RCRA groundwater monitoring plans, IDEQ = Calciner Pond groundwater monitoring plan, CERCLA = Interim CERCLA groundwater monitoring plan.
[2] Impact is in reference to detection of arsenic, nitrate or selenium above representative levels.

5.3 FIELD DUPLICATE GROUNDWATER MONITORING WELL SAMPLE COLLECTION

When collecting duplicate groundwater samples, bottles with two different sample designations will be alternated in the filling sequence.

5.4 MATRIX SPIKE / MATRIX SPIKE DUPLICATE QC SAMPLE COLLECTION

When collecting MS/MSD QC samples, a single sample designation, followed with "A," "B" and "C" suffixes for the primary, MS and MSD sample volumes respectively, will be assigned to a triple-volume sample.

5.5 FIELD BLANK QC SAMPLE COLLECTION

Rinsate blanks will be collected by pumping purified (distilled or deionized) water through the submersible pump setup after decontamination. Distilled or de-ionized water blanks will be collected directly from the field supply container.

5.6 FIELD PARAMETER MEASUREMENTS

Electrical conductivity, water temperature, turbidity and pH measurements will be made in the field during purging and immediately before collection of the water sample. Field parameter measurements are collected using an in-line flow through system as described in Section 5.2.2. A field pH meter with a combination electrode or equivalent will be used for pH measurement. A field conductivity meter will be used for specific conductance measurements. A nephelometer-type turbidimeter will be used for turbidity measurements. Temperature measurements will be performed using standard thermometers or equivalent temperature meters. A combined field meter or individual meters will be used for dissolved oxygen and ORP measurements. Combination instruments capable of measuring multiple parameters may also be used. All instruments will be calibrated in accordance with manufacturers' recommendations. Conductivity standards and pH buffers used in the calibration will be recorded on daily calibration forms associated with each monitoring event. The field parameter measurement, calibration and accuracy requirements are summarized below:

Field Parameter	**Instrument / Method**	**Calibration**	**Estimated Accuracy***
Water Level Survey	Electrical Water Probe Steel Tape	Reference to Steel Tape Reference to New Tape	0.01 ft 0.01 ft
Specific Conductance	Conductivity meter	Daily, single standard (typically 1413 µmhos/cm)	± 0.5% or 1 µmhos/cm
Dissolved Oxygen	Dissolved oxygen meter	Daily, based on local barometric pressure and water-saturated air	± 2% or 0.2 mg/L

ORP	ORP meter	Daily, using ORP buffer solution; solution temperature must also be recorded	± 20 mV
Temperature	Temperature meter	Factory calibration only	0.15 °C
Nephelometric turbidity (NTU)	Turbidity meter	Daily, check against 2 known standards	± 2%
pH	pH meter	Daily, 2- or 3-point with standard buffers (4, 7, 10)	± 0.2 pH unit

*Based on manufacturer specifications for YSI 556 MPS system and HACH 2100P turbidity meter currently used for FMC groundwater monitoring. Alternate instrumentation should have comparable estimated accuracies.

5.7 EQUIPMENT DECONTAMINATION PROCEDURE

Decontamination of sampling equipment will be consistently conducted in a manner to minimize potential cross-contamination and to ensure the quality of samples collected. The resulting decontamination fluids and residual material will be handled in the manner described in Section 7 to minimize potential recontamination of sampling equipment.

All equipment that comes into contact with potentially contaminated water will be decontaminated. Sampling equipment will be washed with a non-phosphate detergent scrub, followed by fresh water and de-ionized water rinses prior to each use. Equipment will be decontaminated in plastic containers, on pallets or plastic sheeting, and clean equipment will be used immediately. Clean equipment that is stored more than a few hours will be decontaminated again prior to use.

Sampling equipment will either be cleaned at the sampling location using non-phosphate detergent followed by fresh water and deionized water rinse, or will be steam-cleaned along with other equipment at a decontamination station.

Sampling equipment will be decontaminated as follows:

1. The exterior surfaces and accessible interior portions of submersible and hand pumps will be steam-cleaned or cleaned with sequential rinses of non-phosphate detergent solution, tap water, and de-ionized water prior to each use. Inaccessible interior portions of the pumps will be cleaned prior to each use by purging the same rinse water sequence through the pump and discharge lines. An effort will be made to sample the wells in the order of least to most contaminated to further minimize the risk of sample cross-contamination.

2. Bailers and tubing used for collection of the groundwater samples will be pre-cleaned and disposed after one use or cleaned at the start of the job and between wells by steam cleaning or with a non-phosphate detergent wash followed by a tap water, and finally, a de-ionized water rinse.

3. Steel tapes, water probes, water level indicators, and transducers will be rinsed in de-ionized water or cleaned in a detergent solution and rinsed once in fresh water after each use.

4. Rinsate blanks will be collected from the submersible pump setup at the frequency specified in Section 3.4.

6.0 SAMPLING HANDLING AND ANALYSIS

This section describes sample handling procedures including sample containers, sample preservation, shipping requirements and holding times, and sample analysis. These procedures are designed to ensure that samples are preserved and transported to the laboratory in a manner that is consistent and maintains sample integrity. Table A-4 summarizes sample containers, preservatives, volume, and holding times for the routine semi-annual groundwater monitoring events, and Table A-5 summarizes the same information for the expanded 5-year monitoring events.

TABLE A-4. SAMPLE HANDLING AND PRESERVATION PROCEDURES FOR ROUTINE SEMIANNUAL MONITORING EVENTS

Parameter	Recommended Container	Preservative	Maximum Holding Time
Water Quality (Cl^-, F^-, NO_3^-, and SO_4^{2-})	0.5-liter polyethylene bottle	Cool to 4°C	28 days
Metals (As, K, Se, and Total phosphorus)	0.25-liter polyethylene bottles	HNO_3 to pH<2, Cool to 4°C	6 months

TABLE A-5. SAMPLE HANDLING AND PRESERVATION PROCEDURES FOR EXPANDED 5-YEAR MONITORING EVENTS

Parameter	Recommended Container	Preservative	Maximum Holding Time
Water Quality (Cl^-, F^-, NO_3^-, and SO_4^{2-})	0.5-liter polyethylene bottle	Cool to 4°C	28 days
Metals (As, K, Se, Mn, B, V and Total phosphorus)	0.25-liter polyethylene bottles	HNO_3 to pH<2[a], Cool to 4°C	6 months
Total Ammonia	0.5-liter polyethylene bottle	H_2SO_4 to pH<2; Cool to 4°C	28 days
Total cyanide	0.5-liter polyethylene bottle	NaOH to pH > 12; Cool to 4°C	14 days

6.1 SAMPLE HANDLING

Sample containers will be pre-cleaned. Preservatives, if required, will be added to the containers prior to shipment of the sample containers to the laboratory or added to the samples(s) in the field as needed to meet sample preservation requirements.

6.2 SAMPLE SHIPMENT

All sample containers will be placed in a strong, rigid-walled shipping container such as a heavy plastic cooler. The following outlines the packaging procedures that will be followed.

1. When ice is used, secure the drain plug of the cooler with tape to prevent melting ice from leaking out of the cooler.
2. Line the cooler with bubble wrap, as needed, to prevent breakage during shipment.
3. Check screw caps for tightness and, if not full, mark the sample volume level of liquid samples on the outside of their sample bottles with indelible ink.
4. Custody-seal all container tops.
5. Affix sample labels onto the containers and write sample number on container with indelible ink.
6. Wrap all glass sample containers in bubble wrap to prevent breakage.

All samples will be placed in coolers with the appropriate chain-of-custody form. All forms will be enclosed in a large plastic bag and affixed to the underside of the cooler lid. Empty space in the cooler will be filled with bubble wrap or Styrofoam peanuts to prevent movement and breakage during shipment. Ice used to cool samples will be placed on top and around the samples to chill them to the correct temperature. Both samples and ice will be double-bagged in large plastic bags. Each ice chest will be securely taped shut with strapping tape; and custody seals will be affixed to the front and back of each cooler.

6.3 SAMPLE ANALYSIS

Required sample analyses and methods for the routine semi-annual groundwater monitoring events are summarized in Table A-6.

TABLE A-6. SUMMARY OF REQUIRED ANALYSES

ROUTINE SEMIANNUAL GROUNDWATER MONITORING EVENTS

Parameter	Method Number	Method Type	Reporting Limit (ppm)
Potassium	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.1
Chloride	9056 (b) or 325.3 (c)	Ion Chromatography or Titrimetric	1
Fluoride	9056 (b) or 340.2 (c)	Ion Chromatography or Potentiometric, Ion Selective Electrode	0.1
Metals (As, Se)	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.002 (As), 0.0005 (Se)
Nitrate	9056 (b) or 353.2 (d)	Ion Chromatography or Colorimetric	0.1
Total Phosphorus	6010B (a) or 365.2 (c)	Inductively Coupled Plasma / Mass Spectrometry or Colorimetric (ascorbic acid)	0.02
Sulfate	9056 (b) or 375.4 (d)	Ion Chromatography or Turbidimetric	1

(a) Analysis may also be performed using method 6020, both 6010B and 6020 from Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(b) Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(c) Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020).

(d) Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100).

The required sample analyses and methods for the expanded 5-year monitoring events are summarized in Table A-7.

TABLE A-7. SUMMARY OF REQUIRED ANALYSES

EXPANDED 5-YEAR GROUNDWATER MONITORING EVENTS

Parameter	Method Number	Method Type	Reporting Limit (ppm)
Potassium	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.1
Chloride	9056 (b) or 325.3 (c)	Ion Chromatography or Titrimetric	1
Fluoride	9056 (b) or 340.2 (c)	Ion Chromatography or Potentiometric, Ion Selective Electrode	0.1
Metals (As, Se, Mn, B and V)	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.002 (As), 0.0005 (Se), 0.0006 (Mn), 0.018 (B), 0.002 (V)
Nitrate	9056 (b) or 353.2 (d)	Ion Chromatography or Colorimetric	0.1
Total Phosphorus	6010B (a) or 365.2 (c)	Inductively Coupled Plasma / Mass Spectrometry or Colorimetric (ascorbic acid)	0.02
Sulfate	9056 (b) or 375.4 (d)	Ion Chromatography or Turbidimetric	1
Total Ammonia (NH_3 + NH_4 as N)	350.3 (d)	Potentiometric, Ion Selective Electrode	0.2
Total Cyanide	335.4 (d)	Colorimetric	0.01

(a) Analysis may also be performed using method 6020, both 6010B and 6020 from Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(b) Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(c) Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020).

(d) Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100).

7.0 DISPOSAL OF WASTE

In the process of collecting groundwater samples, different types of potentially contaminated wastes will be generated. The expected wastes are:

- Used personal protective equipment (PPE).
- Disposable sampling equipment.
- Decontamination fluids.
- Purged groundwater.

This section describes the procedures that will be followed to handle these wastes. The procedures have enough flexibility to allow the sampling team to use its professional judgment on the proper method for the disposal of each type of waste generated at each sampling location.

7.1 USED PPE AND DISPOSABLE SAMPLING EQUIPMENT

Used PPE and disposable equipment will be bagged and accumulated in a dumpster onsite for disposal in the onsite landfill or an appropriate off-site landfill. Any PPE and disposable equipment that could be considered reusable will be rendered inoperable before disposal.

7.2 DISPOSAL OF DECONTAMINATION FLUIDS AND PURGED GROUNDWATER

Due to the low levels of contaminants in groundwater (i.e., analytical results of previous groundwater samples have not exceeded the Toxicity Criteria presented in 40 C.F.R. Part 261 Subpart C), the decontamination fluids and groundwater will be managed as non-hazardous water.

APPENDIX A-A

INTERIM CERCLA GROUNDWATER MONITORING PLAN

WELL COMPLETION DIAGRAMS

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	110

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
Northeastern corner of site	N 453,398.7 E 558,378.9	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
10-3-90	10-3-90	Layne Environmental	AP-1000	10"	101.5	0.0	101.5

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
3.0/67		2	4450.57	4449.3	64.8/4384.5 12-01-90	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140-lbs / 30-in	4-in / 97.5-ft	Curtis Obi

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS / % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4449.3				0 - 5 FT. **GRAVELLY SILT WITH SAND (ML)**: Dark yellowish brown (10 YR 4/2), slightly moist, stiff, with 20% coarse-grained sand and 30% subrounded gravel (diameter ≤ 3 in.).	Dual-wall percussion drilling with reverse air circulation.
SS	1.5	1.5	2 4 14				4444.3	5			5 - 101.5 ft. **GRAVEL WITH SAND (GW)**: Moderate yellowish brown (10 YR 5/4) to pale yellowish brown (10 YR 6/2), dry to wet, loose to medium-dense, well-graded, angular-to-subrounded gravel and cobbles (diameter ≤ 8 in.), with sand.	Air-water mist (<1 gpm) used where needed to restore circulation.
								10				Logged from drill cuttings and from split-spoon samples using the Unified Soil Classification System (ASTM D 2488-84) and the GSA Rock Color Chart.
								15				
								20			Purple quartzite boulder fragments at 18 ft.	
								25				
SS	1.5	0.0	16 22 19					30				
								35				
								40				
								45				
								50				
								55				
								60				
								65				Encountered ground water during drilling at approximately 67 ft below the ground surface.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	8-12-92	110

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	110

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 4" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								75				
								80				
								85				
								90			Bleached shell fragments below 90 ft.	Moderate ground-water discharge from gravel (approx. 10 gpm).
								95				
SS	1.5	1.5	6 8 8				4347.8	100			Silt fraction increases at 100 ft.	
											TOTAL DEPTH: 101.5 FT.	Boring converted to well on 10-3-90.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	8-12-92	110

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	111

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
Northern edge of site	N 452,890.2 E 556,296.9	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
10-11-90	10-11-90	Layne Environmental	AP-1000	10"	110.0	0.0	110.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
1.3/43		1	4468.04	4466.3	▽ 71.7/4394.7 12-01-90 /	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140-lbs / 30-in	4-in / 104.5-ft	Garrett Day

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4466.3				0 - 5 ft. **SILT WITH SAND (ML)**: Grayish brown (5 YR 3/2), dry, with 20% well-graded subrounded sand.	Dual-wall percussion drilling with reverse air circulation.
SS	1.5	1.0	8 11 8				4461.3	5			5 - 15 ft. **SILT (ML)**: moderate brown (5 YR 4/4), slightly moist, slightly plastic, calcareous.	Air-water mist (<1 gpm) used where needed to restore circulation.
								10				Logged from drill cuttings and from split-spoon samples using the Unified Soil Classification System (ASTN D 2488-84) and the GSA Rock Color Chart.
							4451.3	15			15 - 25 ft. **SILT (MH)**: Moderate brown (5 YR 4/4), slightly moist, plastic, calcareous.	
								20				
							4441.3	25			25 - 58 ft. **SILTY SAND WITH GRAVEL (SM)**: Moderate brown (5 YR 4/4), dense, 40% well-graded subangular sand, 30% clayey silt, 30% subangular gravel (diameter ≤ 2 in.).	
SS	1.5	0.3	35 48 50					30				
								35				
								40				
								45				
								50				
								55				
							4408.3				58 - 62 ft. **GRAVEL WITH SAND (GW)**: Dusky brown (5 YR 2/2), 70% well-graded gravel of metamorphic and volcanic lithologies, 30% angular-to-subangular coarse-grained sand, with trace fine-to-medium sand.	
							4404.3	60			62 - 82 ft. **CLAY (CL)**: Dark yellowish brown (10 YR 4/4), moist to wet, slightly plastic, calcareous, silty clay with 10% subrounded medium to coarse-grained sand and trace gravel.	
SS	1.5	1.3	20 25 19					65				

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	8-12-92	111

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	111

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								75				Encountered ground water during drilling at approximately 75 ft below the ground surface.
								80				
							4384.3				82 - 107 ft. **GRAVEL WITH SAND (GW)**: Brownish gray (5 YR 4/1), well-graded subrounded gravel (diameter ≤ 2 in.) with 40-50% well-graded subangular sand, and trace clay.	
								85				85-107 ft: Abundant ground-water discharge.
								90				
								95				
								100				
								105				
							4359.3				107 - 110 ft. **CLAYEY SAND (SC)**: Dark yellowish brown (10 YR 4/4), 60% subangular fine to medium-grained sand with 30% clay, 10% gravel, and trace coarse sand.	
							4356.3	110			TOTAL DEPTH: 110.0 FT.	Boring converted to well on 10-12-90.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	8-12-92	111

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	134

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
North of former Pond 2S	N 451,636.8 E 555,354.2	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
10-29-90	10-29-90	Layne Environmental	AP-1000	10"	116.0	0.0	116.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/		0	4478.93	4477.0	80.6/4396.4 12-01-90 /	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
No samples collected.	4-in / 114.8-ft	Garrett Day

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4477.0					
								4474.0				0 - 3 ft. **SLAG GRAVEL (FILL)**: Medium gray (5N6).	Dual-wall percussion drilling with reverse air circulation.
									5, 10, 15, 20, 25, 30, 35, 40, 45			3 - 48 ft. **SILT (ML)**: Dark yellowish brown (10 YR 4/2), dry, 90% low-plasticity calcareous silt, 10% subangular-to-rounded well-graded sand, with trace gravel.	Air-water mist (<1 gpm) used where needed to restore circulation. Logged from drill cuttings using the Unified Soil Classification System and the GSA Rock Color Chart.
								4429.0	50, 55, 60			48 - 62 ft. **SILTY GRAVEL WITH SAND (GM)** Moderate brown (5 YR 3/4), dry, calcareous, 40% subangular-to-subrounded well-graded gravel (diameter ≤ 3 in.), 40% silt, 40% subangular-to-rounded well-graded sand, with trace boulders.	
								4415.0	65			62 - 95 ft. **SILT (ML)**: Dark yellowish brown (5 YR 4/2), slightly moist, moderately plastic, calcareous, clayey silt with trace sand, gravel, and boulders.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	8-12-92	134

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	134

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								75				
								80				
								85				
								90				
							4382.0	95			95 - 113 ft. **GRAVEL WITH SAND (GW)**: Blackish red (5 R 2/2), wet, 80% angular-to-rounded, well-graded gravel (diameter ≤ 3 in.) of metamorphic and volcanic lithologies, 20% subangular-to-subrounded, well-graded sand, with trace silt and clay.	Encountered ground water during drilling at approximately 96 ft below the ground surface. 100-113 ft: Moderate ground-water discharge.
								100				
								105				
								110				
							4364.0				113 - 116 ft. **CLAY (CL)**: Moderate brown (5 YR 3/4), wet, moderately plastic, moderately calcareous, silty clay with trace sand and gravel.	113-116 ft: Minimal ground-water discharge.
							4361.0	115			TOTAL DEPTH: 116 FT.	
												Boring converted to well on 10-29-90.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: EMF POCATELLO, ID

Last Update: 8-12-92

HOLE NO. 134

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 3	139

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
FMC Corporation	N 450,368.1 E 553,167.0	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
5-12-92	5-13-92	Layne Environmental	AP-1000	10"	161.0	2.0	163.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/			4467.7	4466.3	▽ 72.2/4394.1 6-26-92 /	161.0/4305.3

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lbs. / 30 in.	4" Sch. 40 PVC / 96.0	Garrett Day

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4466.3				0 - 8 ft. **SLAG GRAVEL FILL**: Grayish black (N2); 40% angular, 1/4 to 2" gravel; 40% medium to coarse subangular sand; 20% silty material; dry.	Dual-wall percussion drilling with reverse air circulation. Inner pipe = 6" Outer pipe = 9 3/4" diameter Air-water mist (<1 gpm) used when needed to assist with circulation. Logged from drill cuttings using Unified Soil Classification System and GSA Rock Color Chart.
							4458.3	5			8 - 25 ft. **SILT (ML)**: Dark yellowish brown (10 YR 4/2); 100% clayey silt; trace of gravel; calcareous; moderately plastic; moist	
								10, 15, 20			At 20 feet: Moist to wet.	
							4441.3	25			25 - 46 ft. **SANDY GRAVEL (GW)**: Dark yellowish brown (10 YR 4/2); well graded; 40% angular to subrounded fine gravel to 2" cobbles, metamorphic and quartzitic; 40% fine to coarse angular to subangular sand; 20% silt; dry. At 30-46 feet: Up to 5" broken and non-broken metamorphic and volcanic cobbles.	
								30, 35, 40				
							4420.3	45			46 - 67 ft. **GRAVELLY SILT (ML-GM)**: Dark yellowish brown (10 YR 4/2); 80% calcareous, moderately plastic silt; 20% subrounded, metamorphic and volcanic gravels to 3" cobbles; dry.	
								50, 55, 60			At 55 feet: Gravel layer; 40% angular rhyolitic and andesitic gravels to 1" diameter.	
							4399.3	65			67 - 78 ft. **CLAYEY SILT (ML-MH)**: Moderate brown (5 YR 3/4); 90% clayey silt to sandy silt; 10% coarse sand, to fine subangular.	67 feet: Wet

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 3	139

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
												gravel; calcareous; moderately plastic; wet.	
								4388.3	75				
									80			78 - 86 ft. **SILTY CLAY (CL-CH)**: Pale yellowish brown (10 YR 6/2) mottled with dark yellowish brown (10 YR 4/2); Possible limonite staining; calcareous; moderately plastic; wet.	
								4380.3	85				
									90			86 - 95 ft. **SANDY GRAVEL (GP-GW)**: Dark yellowish brown (10 YR 4/2); 40% 1" to 4" subangular, volcanic and metamorphic gravel; 40% mostly fine sand, some subangular to subrounded medium to coarse sand; 20% clayey silt; wet.	86-93 feet: Abundant ground water discharge.
								4371.3	95			At 93 feet: Clay stringer.	
												At 93-95 feet: Mostly volcanic gravels (rhyolitic, basaltic, andesitic, etc.).	
									100			95 - 130 ft. **SANDY CLAY (CL-SC)**: Dark yellowish brown (10 YR 4/2); 50% silty calcareous clay; 30% fine to coarse subangular sand; 20% fine angular volcanic gravel; wet.	
									105				
									110			At 110 feet: Some hard siltstone with possibly some tuffaceous material; calcareous; gravels are volcanic, olive black (5 Y 2/1) to very dusky red (10 R 2/2); wet.	
									115				
									120			At 120-130 feet: Black manganese oxides present in cuttings.	
									125				
								4336.3	130			130 - 143 ft. **SILT (ML) TO SILTSTONE**: Moderate brown (5 YR 4/4 to 5 YR 3/4); hard; calcareous; with white elongated filling; 10% coarse metamorphic sand to fine subrounded gravel (Possibly very weathered tuff or volcanic ash). Water flow suggests fractured material.	130-143 feet: Abundant ground water discharge.
									135				
									140				
								4323.3	145			143 - 157 ft. **WEATHERED ASH FLOW TUFFS TO CLAY (CL)**: Pale yellowish brown (10 YR 6/2); porphyritic rhyolitic tuff; dark red inclusions; hard; some calcareous; in a dark yellow brown (10 YR 4/2) clay.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE

FMC Corporation

Last Update: 11-10-93

HOLE NO. 139

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	3 OF 3	139

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								155				
							4309.3					
								160			157 - 161 ft. **VOLCANIC GRAVEL (GP)**: Black (N1); 60% volcanic gravel of mainly basalt, rhyolite, some trachyandesite; 25% black basaltic sand, medium to coarse angular grains; 15% porphyritic tuff and minor pitchstone; welded tuff with glass shards and flame structures (fiamme); wet.	157-161 feet: Abundant ground water discharge.
							4305.3					
							4303.3				161 - 163 ft. **BASALT PORPHYRY**: Black (N1), with abundant white, fresh plagioclase phenocrysts up to 3 mm; hard with fresh and weathered cuttings (possibly fractured).	161-163 feet: Hard drilling. Backfilled bottom of hole with cement-bentonite grout (-99 to 163 feet).
											TOTAL DEPTH: 163.0 FT.	Installed 4" monitoring well on 6-13-92.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: FMC Corporation

Last Update: 11-10-93

HOLE NO. 139

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	145

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
FMC Corporation	N 452,188.7 E 557,552.3	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
4-30-92	4-30-92	Layne Environmental	AP-1000	10"	149.0	1.0	150.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
1.5/100		1	4478.3	4477.0	▽ 84.6/4392.4 6-26-92	149.0/4328.0

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lbs. / 30 in.	4" Sch 40 PVC / 142.5	H. Feng

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4477.0				0 - 14 ft. **SANDY GRAVEL (FILL)**: Gray; 50% fine gravel, 50% medium to coarse sand.	Dual-wall percussion drilling with reverse air circulation. Inner pipe = 6" Outer pipe = 9 3/4" diameter. Air-water mist (<1 gpm) used when needed to assist with circulation.
								4463.0	5, 10				
								4461.0	15			14 - 16 ft. **SANDY GRAVEL (GW)**: 60% well rounded black gravel, 50% brown medium to coarse grained sand.	Logged from split spoon sample and drill cuttings using the Unified Soil Classification System and the GSA Rock Color Chart.
									20			16 - 47 ft. **SANDY SILT (ML)**: Brown (10 YR 5/3); 90% very stiff silt, 10% fine sand. At 16 - 40 feet: Moist.	
									25, 30, 35, 40			At 40 - 47 feet: Significant increase in moisture.	
								4430.0	45				
								4427.0	50			47 - 50 ft. **SILTY SAND WITH GRAVEL (SM)**: Grayish brown (10 YR 5/2); 50% medium sand, 30% silt, 20% well rounded coarse gravel.	
									55			50 - 57 ft. **SILTY SAND (SM)**: Brown (10 YR 5/3); 70% coarse sand, some fine to medium sand, 20% silt.	
								4420.0	60, 65			57 - 75 ft. **SAND (SW)**: Reddish gray (5 YR 5/2), subrounded; wet at 75 feet.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	145

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
										At 73 feet: Wet soil.
							4402.0	75	75 - 84 ft. **CLAY (CH)**: Yellowish brown (10 YR 5/4); more than 90% very soft, high plastic clay, less than 10% silt, trace of gravel.	
SS	1.5	1.5	4/6/10					80		
							4393.0	85	84 - 88 ft. **GRAVELLY CLAY (CH)**: Yellowish brown (10 YR 5/4); 70% clay, 20% gravel, 10% silt; wet.	
							4389.0			
							4388.0	90	88 - 89 ft. **VOLCANIC GRAVEL (GW)**: Dark gray to black angular gravels; no fines; moist.	At 88 feet: Moist to wet but no ground water discharge.
								95	89 - 101 ft. **CLAYEY VOLCANIC GRAVEL (GC)**: 50% angular, purple and dark gray to black gravel; 20 - 40% grayish brown clay; 10 - 20% silt to fine sand.	
							4376.0	100		
								105	101 - 116 ft. **SILTY VOLCANIC GRAVEL (GM)**: 50% dark purple and black angular gravels; 40% silt, clay and fine sand mixture.	At 101 feet: Encountered ground water; discharge not significant from 101-116 ft.; drill cuttings are a muddy slurry.
								110		
							4361.0	115		
								120	116 - 129 ft. **GRAVELLY SILT (ML)**: More than 70% of soil cuttings are silt; 10 - 30% dark colored angular gravel (Interval from 89-129 ft. may be volcanic mud flow or agglomerate).	At 116-129 feet: Little or no ground water encountered; cuttings are a muddy slurry.
								125		
							4348.0	130	129 - 140 ft. **SANDY GRAVEL (GW)**: 80% dark colored fine to coarse angular gravels; 10-20% medium to coarse grained sand; no fines.	At 129 - 140 feet: Abundant discharge of ground water.
								135		At 140 - 141 feet: No ground water discharged.
							4337.0	140		At 141 - 144 feet: Abundant discharge of ground water.
							4336.0		140 - 144 ft. **SANDY TO SILTY VOLCANIC GRAVEL**: Dark purple to black angular, volcanic gravel in silty, sandy matrix. At 140-141 ft.: Light gray, fractured tuff; possible boulder.	
							4333.0	145	144 - 150 ft. **GRAVELLY SILT (ML)**: 10-20% volcanic gravel; some clay. At 149-150 ft.:Light gray tuff.	At 144 - 149 feet: Minor ground water discharge
							4328.0			Installed 4" PVC monitoring well on 5-6-92
							4327.0		TOTAL DEPTH: 150 FT.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: FMC Corporation

Last Update: 11-10-93

HOLE NO. 145

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	146

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
FMC Corporation	N 453,214.1 E 557,382.2	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
4-21-92	4-22-92	Layne Environmental	AP-1000	10"	108.5	0.0	108.5

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
2.5/83		2	4459.3	4457.9	68.6/4389.3 6-26-92 /	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lbs. / 30 in.	4" Sch. 40 PVC / 107.5	H. Feng

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4457.9				0 - 5 ft. **CLAYEY SILT (ML)**: Brown.	Dual-wall air percussion drilling with reverse air circulation.
								4452.9	5			5 - 10 ft. **CLAYEY GRAVEL (GC)**: With cobbles of 3" or greater.	Inner pipe = 6"
								4447.9	10			10 - 20 ft. **GRAVELLY SILT (GM-ML)**: 60% silt, 30% gravel, 10% clay.	Outer pipe = 9 3/4" diameter. Air-water mist (<1 gpm) used when needed to assist with circulation.
								4437.9	20			20 - 30 ft. **SILTY GRAVEL (GM)**: 70% gravel, 20% silt, 10% sand, < 5% clay.	Logged from drill cuttings and from split-spoon samples using the Unified Soil Classification System and GSA Rock Color Chart.
								4427.9	30			30 - 35 ft. **GRAVEL WITH COBBLES (GP)**: 70% gravel, 20% boulders and cobbles.	
								4422.9	35			35 - 60 ft. **SILTY GRAVEL (GM)**: 60% angular gravel, 20% fine-grained sand, 20% silt, trace of cobbles of 3" or greater.	
								4397.9	60			60 - 71 ft. **CLAYEY SILT (ML)**: Light yellowish brown (10 YR 6/4); 70% silt, 20% clay, some fine-grained sand; very moist.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
FMC Corporation	11-10-93	146

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	146

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6" / % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
SS	1.5	1.0	16-26-37				4386.9					
											71 - 76 ft. **SANDY GRAVEL (GP)**: Light brown (7.5 YR 6/2); 60% gravel, 30% coarse-grained sand, <10% clay.	At 70 feet: Observed saturation in drill cuttings.
							4381.9	75				
											76 - 80 ft. **SILTY CLAY (CL)**: Gray (N6).	At 76 - 80 feet: Cuttings returned as slurry.
SS	1.5	1.5	4-12-40				4377.9	80				
											80 - 101 ft. **GRAVEL AND SAND (GP)**: Light brownish gray (2.5YR 6/2), roughly 50% gravel, 50% sand, traces of cobbles.	At 80 - 101 feet: Abundant ground water discharge.
								85				
								90				
								95				
							4356.9	100				
											101 - 105 ft. **SANDY GRAVEL (GP)**: 80% reddish brown (5YR 4/4) gravel, 20% brownish gray (2.5YR 6/2) sand.	At 101 - 105 feet: Abundant ground water discharge.
							4352.9	105				
											105 - 108.5 ft. **SANDY SILT (ML)**: Grayish brown (2.5Y 5/2) with clay pockets.	
							4349.4					
											TOTAL DEPTH: 108.5 FT.	Installed 4" monitoring well on 4-22-92.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: FMC Corporation

Last Update: 11-10-93

HOLE NO. 146

GEOLOGIC DRILL LOG

PROJECT: EMF POCATELLO, ID	JOB NO. 21372	SHEET NO. 1 OF 2	HOLE NO. 151		
SITE: FMC Corporation	COORDINATES and/or STATIONINGS: N 450,773.5 E 555,023.3	ANGLE FROM HORIZ: Vertical	BEARING: ------		
BEGUN: 4-25-92	COMPLETED: 4-25-92	DRILLER: Layne Environmental	DRILL MAKE AND MODEL: AP-1000	SIZE: 10"	OVERBURDEN: 136.0
ROCK (FT.): 2.0	TOTAL DEPTH: 138.0	CORE RECOVERY (FT./%): 14.5/97	CORE BOXES:	SAMPLES: 12	EL. TOP CASING: 4501.4
GROUND EL.: 4499.9	DEPTH/EL. GROUND WATER: 105.9/4394.0 6-26-92	DEPTH/EL. TOP OF ROCK: 136.0/4363.9	SAMPLE HAMMER WEIGHT/FALL: 140 lbs. / 30 in.	CASING LEFT IN HOLE: DIA./LENGTH: 4" Sch. 40 PVC / 137.5	LOGGED BY: H. Feng

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4499.9				0 - 13 ft. **FILL**: Dark gray (5 YR 4/1) very angular slag gravel.	Dual-wall percussion drilling with reverse air circulation. Inner pipe = 6" Outer pipe = 9 3/4" diameter. No water added during drilling.
							4486.9	5, 10			13 - 19 ft. **GRAVELLY PEAT (PT)**: Black, wet.	Split-spoon samples are taken with the 2.5" diameter, 2' long Modified California Sampler with brass liners.
SS	1.5	0.5	19-20-25				4480.9	15			19 - 25 ft. **SILT (ML)**: Brown (7.5YR 5/4); 90% silt, 10% sand.	2 glass-jar soil samples taken at each split-spoon sampling point.
SS	1.5	1.5	8-8-9				4474.9	20, 25			25 - 66 ft. **SILT (ML)**: Brown (7.5YR 5/4); more than 90% silt; very consistent and uniform; trace of dark gravel; very stiff; moist.	After each one-foot drilling increment, cuttings were blown out and collected for logging of soil moisture and texture, using Unified Soil Classification System and GSA Rock Color Chart.
SS	1.5	1.5	11-10-10					30, 35, 40				
SS	1.5	1.3	9-11-15					45, 50				
SS	1.5	1.5	9-11-15					55, 60				
							4433.9	65			66 - 76 ft. **SILTY GRAVEL (GM)**: Brown; 60% silt, 40% coarse rounded gravel; very dense; moist.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: FMC Corporation

Last Update: 11-10-93

HOLE NO. 151

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	151

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
SS	1.5	0.7	21-24-26									
							4423.9	75				
											76 - 101 ft. **SANDY SILT (ML)**: Brown (7.5YR 5/4); more than 80% silt, < 20% fine-grained sand, trace gravel; very stiff to hard; abrupt increase in moisture content at 76 ft., thereafter increasingly moist with depth.	
SS	1.5	1.5	19-21-22					80				
								85				
SS	1.5	1.5	20-17-21					90				
								95				
SS	1.5	1.5	26-24-44				4398.9	100				
							4395.9				101 - 104 ft. **GRAVELLY SILT (ML)**: Light brown (7.5 YR 6/4); 75% silt, 25% gravel; saturated.	
								105			104 - 110 ft. **SILT (ML)**: Dark brown (7.5YR 4/2); 80% silt, 10% clay, 10% fine-grained sand.	
SS	1.5	1.5	6-13-21				4389.9	110			110 - 114 ft. **SILTY CLAY (CL)**: Light gray (10 YR 7/1); 70% clay, 30% silt; hard.	At 109 feet: Ground-water encountered during drilling.
							4385.9	115			114 - 120 **CLAY (CL)**: Pale olive (5 Y 6/4); 75% clay, 25% silt, very stiff; trace of gravel and sand.	
SS	1.5	1.5	7-8-16									
O	1.5		GRAB				4379.9	120			120 - 125 ft. **CLAYEY GRAVEL (GC)**: Light gray (10 YR 7/2); 70% angular to subrounded gravel, 30% clay.	At 118 feet: Ground-water sample taken with bailer. At 120-125 feet: Negligible ground-water discharge.
							4374.9	125			125 - 136 ft. **SANDY GRAVEL (GP-GW)**: 75% subrounded gravel, 20% fine-grained sand, 5% silt.	At 125-136 feet: Abundant ground water discharge.
								130				
							4363.9	135				
							4361.9				136 - 138 ft. **GRAVELLY SILT (ML)**: Light yellowish brown (10YR 6/4); very hard, strongly cemented, some gravel (possible tuff).	Installed 4" PVC monitoring well on 4-26-92.

TOTAL DEPTH: 138.0 FT.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: FMC Corporation

Last Update: 11-10-93

HOLE NO. 151

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	159

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
FMC Corporation	N 451,036.0 E 554,680.1	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
6-26-93	6-26-93	Layne Environmental	AP-1000	10"	126.0		126.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/		1	4491.79	4490.0	▽ 95.2/4394.8 6-26-93 /	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lbs. / 30 in.	4" PVC / 123.5 ft.	Dave Kyllonen

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4490.0					
								4489.5				0 - 0.5 ft. **SLAG GRAVEL (Fill)**: Medium light gray (N6).	Dual-wall percussion drilling with reverse air circulation
									5			0.5 - 12 ft. **GRAVELLY SILT (ML)**: Dark yellowish brown (10 YR 4/2), floury, with 20-30% volcanic gravel to 1/2", subangular to subrounded; dry.	Inner pipe = 6" I.D.
									10				Outer pipe = 9 3/4" O.D.
								4478.0				12 - 48 ft. **SILT (ML)**: Moderate yellowish brown (10 YR 5/4), floury, dry.	
									15				
									20				
									25				
									30				
									35			At 35 feet, trace fine gravel.	
									40				
									45				
								4442.0				48 - 52 ft. **CLAYEY SILT (CL-ML)**: Moderate yellowish brown (10 YR 5/4), slightly plastic, floury, slightly moist.	
									50				
								4438.0				52 - 72 ft. **SILTY SANDY GRAVEL (GW-GM)**: Multicolored quartzite gravel, moderate yellowish brown (10 YR 5/4), silt and sand; well graded gravel up to 8" diameter, subrounded to subangular cobbles, some particles flat and elongated; with fine grained sand and 15-20% silt; slightly moist.	
									55				
									60			At 60 feet, silt content decreases to 5-10%, gravels become finer, few large gravel or cobbles.	
									65				

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

Logged from split-spoon samples

SITE	Last Update:	HOLE NO.
FMC Corporation	11-10-93	159

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	159

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6" / % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4418.0			and drill cuttings using Unified Soil Classification System and GSA Rock Color Chart At 68 feet, discharge pipe plugged with cobble fragment.
								75	72 - 89 ft. **CLAYEY SILT (CL-ML)**: Moderate yellowish brown (10 YR 5/4), slightly plastic, slightly moist.	
								80		
								85		
							4401.0			
								90	89 - 105 ft. **SILTY CLAY (ML-CL)**: Moderate yellowish brown (10 YR 5/4), 10-20% silt, medium plasticity, moist to wet.	At 88 feet, discharge pipe plugged by 6" rubble.
SS	1.5	1.5	11 17 20					95	At 95 feet, some 2" gravel.	At 95 feet, wet.
								100	At 102 feet, becomes pale yellowish brown (10 YR 6/2) and highly plastic, 10% silt.	At 96 feet, took split spoon sample at top of water bearing interval.
							4385.0	105	105 - 110 ft. **SILTY SANDY GRAVEL (GP-GM)**: Multicolored quartzite sand and gravel with moderate yellowish brown (10 YR 5/4) silt; gravel is 1/2" - 3/4" and subangular to subrounded; with 10-15% fine grained sand and 10% silt; saturated.	
							4380.0	110	110 - 124 ft. **SANDY GRAVEL (GW)**: Multicolored quartzite, gravels 1/2" - 2", mostly 1/2" - 1", 10-20% coarse sand, 5-10% fine to medium sand; saturated.	At 109 feet, started to produce some water. Volume increasing with depth.
								115		
								120		
							4366.0			
							4364.0	125	124 - 126 ft. **SANDY CLAY (CL)**: Pale yellowish brown (10 YR 6/2), 10-15% fine grained sand, < 5% gravel, gravel is 1/4" and subangular to subrounded; wet.	At 124 feet, stopped producing water. Installed 4" monitoring well on 6-26-93.
									TOTAL DEPTH: 126 FT.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: FMC Corporation

Last Update: 11-10-93

HOLE NO. 159

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	502

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
North of Highway 30	N 454,363.3 E 558,079.5	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
5-18-92	5-18-92	Boyles Brothers	Schramm T685	9"	74'	0'	74.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/			4441.3	4439.3	55.6/4383.7 6-26-92 /	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
	4" PVC / 72 feet	D. B. McCullar

(Template: BCHILLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4439.3					
								4435.3				0 - 4 ft. **SANDY GRAVEL (GW)**: Pale yellowish brown (10 YR 6/2), angular to subround, medium to very coarse sand, granules and pebbles to 1 cm, quartzite and occasional (< 5%) basalt; roots near surface.	Drilling with compressed air, using 7-1/2" Halco down-hole hammer and 9" outer casing.
								4434.3	5			4 - 5 ft. **SILT (ML)**: Pale yellowish brown (10 YR 6/2), very calcareous, floury, dry (loess).	
								4430.3	10			5 - 9 ft. **SILTY GRAVEL (GM)**: Pale yellowish brown (10 YR 6/2), calcareous silt, very coarse sand, gravel granules and pebbles, cobbles and boulders, angular to round.	Very slow drilling, boulders (12" diameter) visible in open hole.
									15			9 - 36 ft. **GRAVEL (GW)**: Multicolored granules and pebbles to 2 cm, angular to subround, consisting of quartzite with 20% basalt. Cobbles and boulders probably present.	Very slow drilling.
									20				Description and classification are from logging of cuttings blown from hole; logged using Unified Soil Classification System and GSA Rock Color Chart.
									25				
									30				
								4403.3	35			36 - 60 ft. **SANDY GRAVEL (GW)**: Various colors, subangular to subround quartzite and 10% basalt granules and pebbles to 2 cm; with medium to very coarse sand, subangular to subround, quartzose; dry.	
									40				
									45			From 43 to 45 feet, gravels are coated with dark yellowish brown (10 YR 4/2) silt; granules and pebbles slightly moist. At 46 feet, silty sandy gravel, 20% silty sand, gravel granules and pebbles to 2 cm; dry.	
									50				
									55				
								4379.3	60			60 - 62 ft. **GRAVEL (GW)**: Various colors, angular to subround, granules and pebbles to 2 cm, composed of quartzite and < 10% basalt.	Making water.
								4377.3	65			62 - 71 ft. **SANDY GRAVEL (GW)**: Pale yellowish brown (10 YR 6/2) subangular to subround, silty coating, medium to very coarse sand granules and pebbles to 1 cm, wet.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	11-12-92	502

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	502

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4368.3					
							4365.3				71 - 74 ft. **SILTY CLAY (CL)**: Pale yellowish brown (10 YR 6/2) to moderate yellowish brown (10 YR 5/4), moist, firm, slightly sandy.	
											Bottom of Hole = 74 ft.	Installed 4" PVC monitoring well to a depth of 72 ft. on 5-19-92.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
EMF POCATELLO, ID	11-12-92	502

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 2	515

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
Offsite	N 454,045.1 E 555,307.3	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
7-21-93	7-21-93	Layne Environmental	AP-1000	10"	86.0		86.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/		1	4450.0	4450.3	51.0/4399.3 /	/

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lbs. / 30 in.	4" PVC / 84.2 ft.	D. B. McCullar

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN. CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6" % CORE RECOVERY	WATER PRESSURE TESTS LOSS G.P.M.	PRESS. P.S.I.	TIME MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4450.3					
							4447.3				0 - 3 ft. **SANDY GRAVEL (GW)**: Dark yellowish brown (10 YR 4/2), coarse sand, granules and pebbles to 1 inch, round to subround, quartzite, very moist to wet.	Dual wall percussion drilling with reverse air circulation. Diameter of inner pipe is 6"; outer pipe is 9 3/4".
								5			3 - 8 ft. **SILT (ML)**: Moderate yellowish brown (10 YR 5/4) wet, slightly sandy.	
							4442.3				8 - 46 ft. **GRAVEL (GW)**: Various colors, granules and pebbles to 1 1/2 inches, subangular to subround, 10% coarse sand, moderate yellowish brown. Below 10 feet, cobble size increases to 5 inches, quartzite with occasional basalt. Below 30 feet, cobbles increases to 6 inches. Slightly silty at 42 feet, grading siltier.	Lithologic descriptions logged from split spoon samples and cuttings using the Unified Soil Classification System, and the GSA Rock Color Chart.
								10				
								15				
								20				
								25				
								30				
								35				
								40				
							4404.3	45				
								50			46 - 53 ft. **SILTY GRAVEL (GM)**: Moderate yellowish brown , silt covered gravels, mixture of quartzite and basalt granules and pebbles to 2 1/2 inches. Becomes wet at 50 feet and saturated below 51 feet, large cobbles to 6 inches.	Ground water at approximately at 51 feet.
							4397.3					
SS	1.5	1.5	45 5 10 9					55			53 - 67 ft. **CLAY (CH)**: Olive gray (5 Y 4/1) changing to dusky brown (5 YR 2/2) at 55.2 feet then changes to gravelly clay (CH), dark yellowish brown (10 YR 4/2) with wood pieces 1 inch long, blackened on outside. Changes back to clay (CH), light olive gray (5 Y 5/2) at 55.8 feet, firm, very moist, moderate to high plasticity, changes color to yellowish gray (5 Y 7/2) at 56.1 feet, siltier, firm. Below 65 feet, clay cuttings are massive 8 inches across, very firm.	
								60				
								65				
							4383.3				67 - 70 ft. **SAND (SP)**: Moderate yellowish brown (10 YR 5/4), fine to medium, moist to wet.	Ground water at approximately at 67 feet.
							4380.3					

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
Offsite	11-10-93	515

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 2	515

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								75 80 85			70 - 86 ft. **SANDY GRAVEL (GW)**: Moderate yellowish brown (10 YR 5/4), 25% medium to coarse sand, quartzite granules and pebbles to 1 inch, increasing to 2 inches below 73 feet.	
							4364.3				TOTAL DEPTH : 86 FT.	Water very dark (dusky brown)

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
Offsite	11-10-93	515

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 of 2	517

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
North of Highway 30	N 453,747.0 E 558,812.8	-90	N00.0E

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
7-7-93	7-7-93	Layne Environmental	AP-1000	10"	79.5		79.5

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	ELEV TOP CASING	GROUND ELEV.	DEPTH / ELEVATION GROUND WATER	DEPTH / ELEVATION TOP OF ROCK
/		0	4444.45	4442.5	58.5/4384 7-7-93 /	/

SAMPLE HAMMER WEIGHT / FALL	CASING LEFT IN HOLE: DIAMETER / LENGTH	LOGGED BY:
	4" PVC / 78.4 ft.	Dave Kyllonen

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								5, 10, 15			0 - 16 ft. **SILTY GRAVEL with SAND (GM):** Multicolored quartzite and volcanics, moderate yellowish brown (10 YR 5/4) silt, gravel to 1 1/2", mostly < 1/2", sand is fine to coarse grained, mostly coarse grained, 20% silt; particles subrounded to subangular; slightly moist near surface, becomes dry at depth. At 10 feet, silt content decreases to 10-20%.	Dual wall percussion drilling with reverse air circulation. Inner pipe = 6" ID. Outer pipe = 9 3/4" OD. Logged from split spoon samples and drill cuttings using the Unified Soil Classification System and the GSA Rock Color chart.
							4426.5	20, 25, 30, 35			16 - 38 ft. **GRAVEL (GP):** Multicolored quartzite and volcanics, gravel to 3", cobbles to 6", sand is fine to coarse grained, gravel mostly < 3/4", < 5% silt; particles subangular to subrounded; dry. At 36 feet, silt content increases to 5-10%.	
							4404.5	40, 45, 50, 55, 60, 65			38 - 79.5 ft. **GRAVELLY SAND (SP):** Multicolored quartzite an volcanics, fine to coarse grained sand, mostly coarse grained, gravel to 3", some 4" cobbles, 5-10% silt; particles subangular to rounded; dry. At 50 feet, a 6" vesicular basalt cobble along with other 4"-5" volcanic and quartzite cobbles. At 65 feet, gravel mostly 1/4" - 1/2", very little sand.	At 60 ft., gravel is wet. Blew some water after adding more casing at 60 feet.

SS = Split Spoon; ST = Shelby Tube; D = Dennison; P = Pitcher; O = Other

SITE	Last Update:	HOLE NO.
North of Highway 30	8/19/93	517

Report Form: EMF IDAHO

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 of 2	517

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								75				Not producing any water At 75 ft., after clearing plugged discharge line, began to produce 5-10 gpm.
							4363.0				TOTAL DEPTH : 79.5 FEET. **TOTAL DEPTH = 79.5 FEET**	Installed 4" monitoring well on 7-7-93.

SS = Split Spoon; ST = Shelby Tube; D = Dennison; P = Pitcher; O = Other

SITE	Last Update:	HOLE NO.
North of Highway 30	8/19/93	517

Report Form: EMF IDAHO

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 3	523

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
OFF SITE	N 452,001.4 E 552,513.7	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
6-12-94	6-12-94	Layne Environmental	AP-1000	10"	90.0	0.0	90.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/na	0	0	4452.98	4450.8	55.0/4395.8 /	na/na

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
na	4 in / 85.5 ft	C. Obi

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS GPM	PRESS. P.S.I.	TIME MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4450.8				0 - 5 ft. **SANDY SILT (ML):** Grayish orange (5 YR 7/2); 20% fine to coarse grained sand; soft, dry.	Borehole drilled with dual-wall percussion-hammer drill rig. Cuttings expelled from boring using reverse-air circulation.
							4445.8	5			5 - 15 ft. **SILTY GRAVEL (GM):** Grayish orange (5 YR 7/2); angular to rounded gravel to 3 inches; 20-40% silt; loose, dry.	Soil descriptions based on visual observations of cuttings following the Unified Soil Classification System (USCS) and the Geological Society of America (GSA) Rock Color Chart.
								10				
							4435.8	15			15 - 44 ft. **SANDY GRAVEL (GP):** Grayish orange (5 YR 7/2); angular to rounded gravel to 6 inches; 30% fine to coarse grained sand; 10% silt; loose, dry.	
								20				
								25				
								30			Moist below 31 ft.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
OFF SITE	7-11-94	523

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 3	523

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								40				
							4406.8	45			44 - 68 ft. **SILT (ML)**: Moderate yellowish brown (10 YR 5/4); medium plasticity, soft, wet.	
								50				
								55				
								60				
								65				
							4382.8	70			68 - 89 ft. **SANDY GRAVEL (GP)**: Subangular to rounded multicolored gravel; 20% fine to coarse grained sand; loose, wet, abundant muddy water.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: OFF SITE

Last Update: 7-11-94

HOLE NO. 523

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	3 OF 3	523

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
									80				
									85				
								4361.8					
								4360.8	90			89 - 90 ft. CLAY (CL): Moderate yellowish brown (10 YR 5/4); 10% fine to coarse grained sand; medium plasticity, soft to stiff, wet.	
												TOTAL DEPTH: 90 FT.	Borehole 523 completed as monitoring well 523 on 6-13-94 using 4" Sch 40 PVC and screened between depths of 75 and 85 ft. See well construction diagram for completion details.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: OFF SITE

Last Update: 7-11-94

HOLE NO. 523

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 4	524

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
OFF SITE	N 455,307.0 E 560,768.0	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
6-14-94	6-14-94	Layne Environmental	AP-1000	10"	120.0	2.0	122.0

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/na	0	0	4399.92	4397.4	20.0/4377.4 /	120.0'/4277.4'

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
na	4 in / 59 ft	C. Obi

(Template: BCHTLLS)

SAMP TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
							4397.4				0 - 8 ft. **GRAVELLY SILT (ML)**; Moderate yellowishbrown (10 YR 7/4); 20% subangular to rounded gravel to 3 inches; 0-20% fine to coarse grained sand; soft, dry.	Borehole drilled with dual-wall percussion-hammer drill rig. Cuttings expelled from boring using reverse-air circulation. Soil descriptions based on visual observations of cuttings following the Unified Soil Classification System (USCS) and the Geological Society of America (GSA) Rock Color Chart.
							4389.4	5			8 - 112 ft. **SILTY GRAVEL (GM)**; Moderate yellowish brown (10 YR 7/4); relatively uniform deposit of multicolored angular fragments to rounded cobbles to 6 inches; 10-20% fine to coarse grained sand; 20-30% silt; loose, dry.	
								10				
								15				
								20			Wet below 20 ft., abundant muddy water.	
								25				
								30				

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
OFF SITE	7-11-94	524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	2 OF 4	524

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								40				
								45				
								50				
								55				
								60				
								65				
								70				

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: OFF SITE

Last Update: 7-11-94

HOLE NO. 524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	3 OF 4	524

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS "N" % CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M.	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								80				
								85				
								90				
								95				
								100				
								105				
								110				
							4285.4				112 - 120 ft. **CLAY (CH)**: Grayish orange pink (5 YR 7/2) to moderate brown (5 YR 4/4); 0-20% fine to coarse grained sand; high plasticity; stiff, moist to wet.	

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE: OFF SITE

Last Update: 7-11-94

HOLE NO. 524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	4 OF 4	524

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN. CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4277.4	120				
								4276.4				120 - 121 ft. **FRACTURED BASALT:** Black vesicular basalt, hard, with calcite and mud-encrusted fractures.	
								4275.4				121 - 122 **BASALT:** Black vesicular basalt, very hard.	
												TOTAL DEPTH: 122 FT.	
													Borehole 524 was allowed to cave from 122 to 59 ft then completed as monitoring well 524 on 6-14-94 using 4" Sch 40 PVC and screened between depths of 48.5 to 58.5 ft. See Well construction diagram for completion details.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
OFF SITE	7-11-94	524

GEOLOGIC DRILL LOG

PROJECT	JOB NO.	SHEET NO.	HOLE NO.
EMF POCATELLO, ID	21372	1 OF 1	525

SITE	COORDINATES and/or STATIONINGS	ANGLE FROM HORIZ	BEARING
OFF SITE	N 455,296.9 E 560,772.1	Vertical	------

BEGUN	COMPLETED	DRILLER	DRILL MAKE AND MODEL	SIZE	OVERBURDEN	ROCK (FT.)	TOTAL DEPTH
6-15-94	6-15-94	Layne Environmental	AP-1000	10"	28.5	0.0	28.5

CORE RECOVERY (FT./%)	CORE BOXES	SAMPLES	EL. TOP CASING	GROUND EL.	DEPTH/EL. GROUND WATER	DEPTH/EL. TOP OF ROCK
/na	0	1	4399.61	4397.1	15.0/4382.1 /	na/na

SAMPLE HAMMER WEIGHT/FALL	CASING LEFT IN HOLE: DIA./LENGTH	LOGGED BY:
140 lb / 30 in	4 in / 28.3 ft	C. Obi

(Template: BCHTLLS)

SAMP. TYPE AND DIAM.	SAMP. ADV. LEN CORE	SAMPLE REC. CORE REC.	SAMPLE BLOWS 6"	% CORE RECOVERY	WATER PRESSURE TESTS: LOSS IN G.P.M	PRESS. P.S.I.	TIME IN MIN.	ELEV.	DEPTH	GRAPHICS	SAMPLE	DESCRIPTION AND CLASSIFICATION	NOTES ON: WATER LEVELS, WATER RETURN, CHARACTER OF DRILLING, ETC.
								4397.1				0 - 4 ft **GRAVELLY SILT (ML):** Moderate yellowish brown (10 YR 7/4); 20% subangular to rounded gravel to 3 inches; 0-20% fine to coarse grained sand; soft, dry.	Borehole drilled with dual-wall percussion-hammer drill rig. Cuttings expelled from boring using reverse-air circulation.
								4393.1				4 - 28.5 ft. **SILTY GRAVEL (GM):** Moderate yellowish brown (10 YR 7/4); angular to rounded multicolored gravel to 6 inches; 10-20% fine to coarse grained sand; 20-30% silt; loose, dry.	Soil descriptions based on visual observations of cuttings following the Unified Soil Classification System (USCS) and the Geological Society of America (GSA) Rock Color Chart.
									5				
									10				
SS	1.5	0.4	15-25-32						15			Wet below 15 ft., abundant muddy water.	
									20				
									25				
								4368.6				TOTAL DEPTH: 28.5 FT.	Borehole 525 completed as monitoring well 525 on 6-15-94 using 4" Sch 40 PVC and screened between depths of 17.8 and 27.8 ft. See well construction diagram for completion details.

SS = SPLIT SPOON; ST = SHELBY TUBE
D= DENNISON P = PITCHER O = OTHER

SITE	Last Update:	HOLE NO.
OFF SITE	7-11-94	525

GEOLOGIST'S LOG

(An interpretative combination of the sample, core, driller, and geophysical logs)

Well 9S Project FMC - Pocatello Page ____ of ____

Date/ Time	Lithologic Unit Description	Lithologic Unit Depth Below Land Surface from (ft)	to (ft)
12/13/80	Alluvium	0	9
	Boulders and gravel	9	52
	Volcanic ash flow	52	55
	Gravel, medium and subrounded	55	62
	Volcanic ash flow	62	66
	Gravel and light brown clay	66	75
	Gravel, larger grain size, no clay present.		
	Water bearing zone.	75	80

(An interpretative combination of the sample, core, driller, and geophysical logs)

Well 11I Project FMC - Pocatello Page ____ of ____

Date/ Time	Lithologic Unit Description	Lithologic Unit Depth Below Land Surface from (ft)	to (ft)
3/81	Light brown silt with small to large gravel	0	5.0
	Boulder	5.0	6.0
	Gravel, small to large, multicolored, with light brown silt	6.0	11.3
	Boulder	11.3	13.0
	Gravel, small to large with cobbles and light brown silt	13.0	28.0
	Boulder	28.0	29.0
	Gravel, small to large, cobbles small boulders and light brown silt	29.0	102.0
	Light brown clayey silt with medium sized gravel	102.0	115.0
	Gravel with medium to coarse sand and clayey silt. Gravel is subrounded and angular, Sample resembles tallus	115.0	118.0
	Rhyolite, gray porphoritic cavity between 121 and 123 feet	118.0	135 TD
	Note: Open hole 5-5/8-inch diameter between 126 and 135 ft. below land surface. Static water level 37.91 ft. below land surface		

(An interpretative combination of the sample, core, driller, and geophysical logs)

Well 12S Project FMC-Pocatello Page ____ of ____

Date/ Time	Lithologic Unit Description	Lithologic Unit Depth Below Land Surface from (ft)	to (ft)
11/9/81	Light brown silt and gravel	0	3
	Gravel, small to large with cobbles, boulders and light brown silt	3	62 TD
	Note: Water encountered at 52 feet while drilling. Screened with a 6-inch diameter 20' slot stainless steel well screen		

MONITORING WELL

PROJECT	WELL NO.
EMF POCATELLO, ID	110

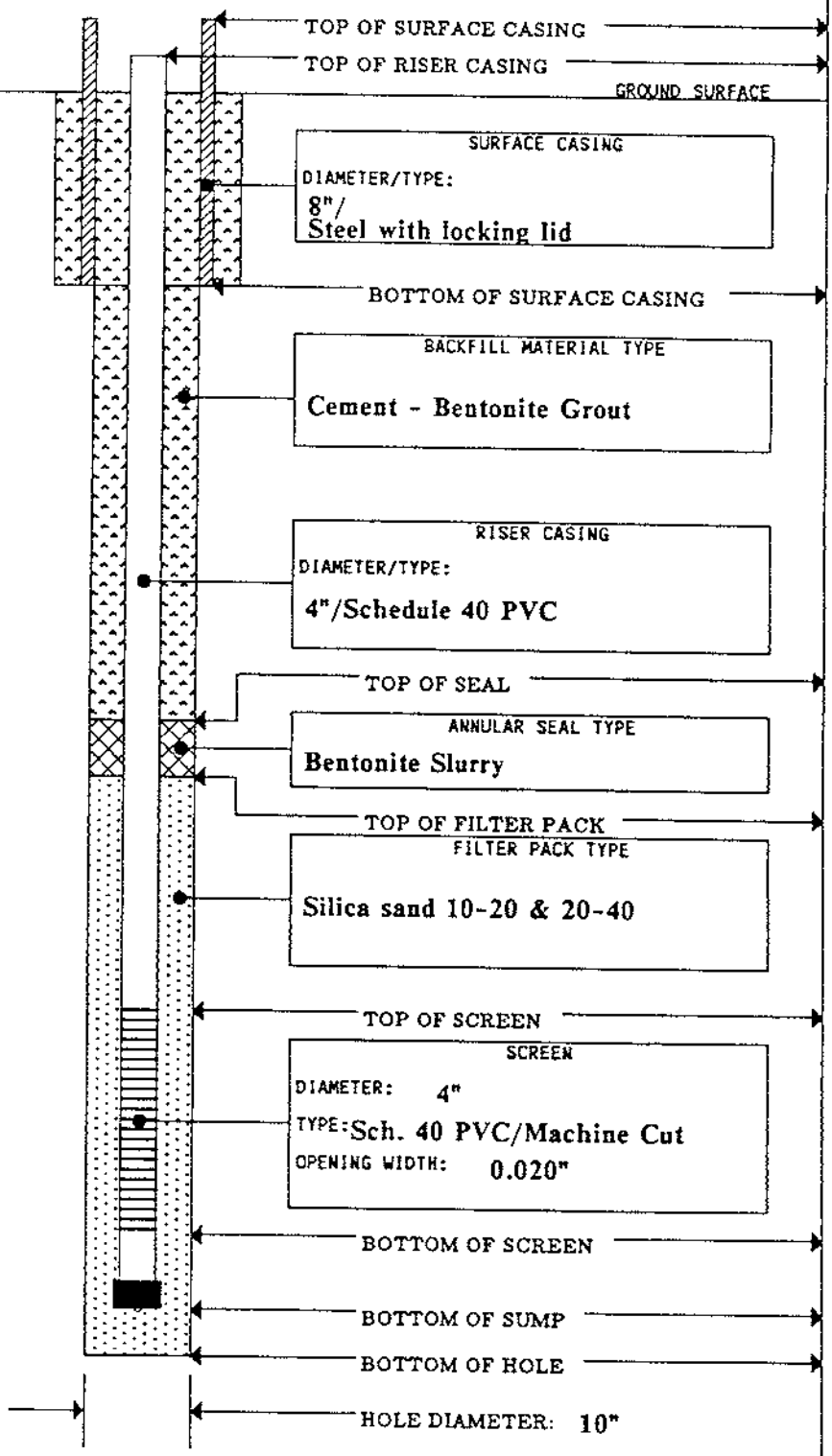
JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	Northeastern corner of site	N 453,398.7 E 558,378.9

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
10-3-90	10-3-90	Curtis Obi	Top of PVC casing(Water level)

(GENERALIZED GEOLOGIC LOG)

See Boring Logs.

NOT TO SCALE



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	1.7	4451.0
TOP OF RISER CASING	1.3	4450.6
GROUND SURFACE	0.0	4449.3
BOTTOM OF SURFACE CASING	3.3	4446.0
TOP OF SEAL	69.0	4380.3
TOP OF FILTER PACK	73.0	4376.3
TOP OF SCREEN	85.0	4364.3
BOTTOM OF SCREEN	95.0	4354.3
BOTTOM OF SUMP	97.5	4351.8
BOTTOM OF HOLE	101.5	4347.8

Update: 8-12-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

PROJECT	WELL NO.
EMF POCATELLO, ID	111

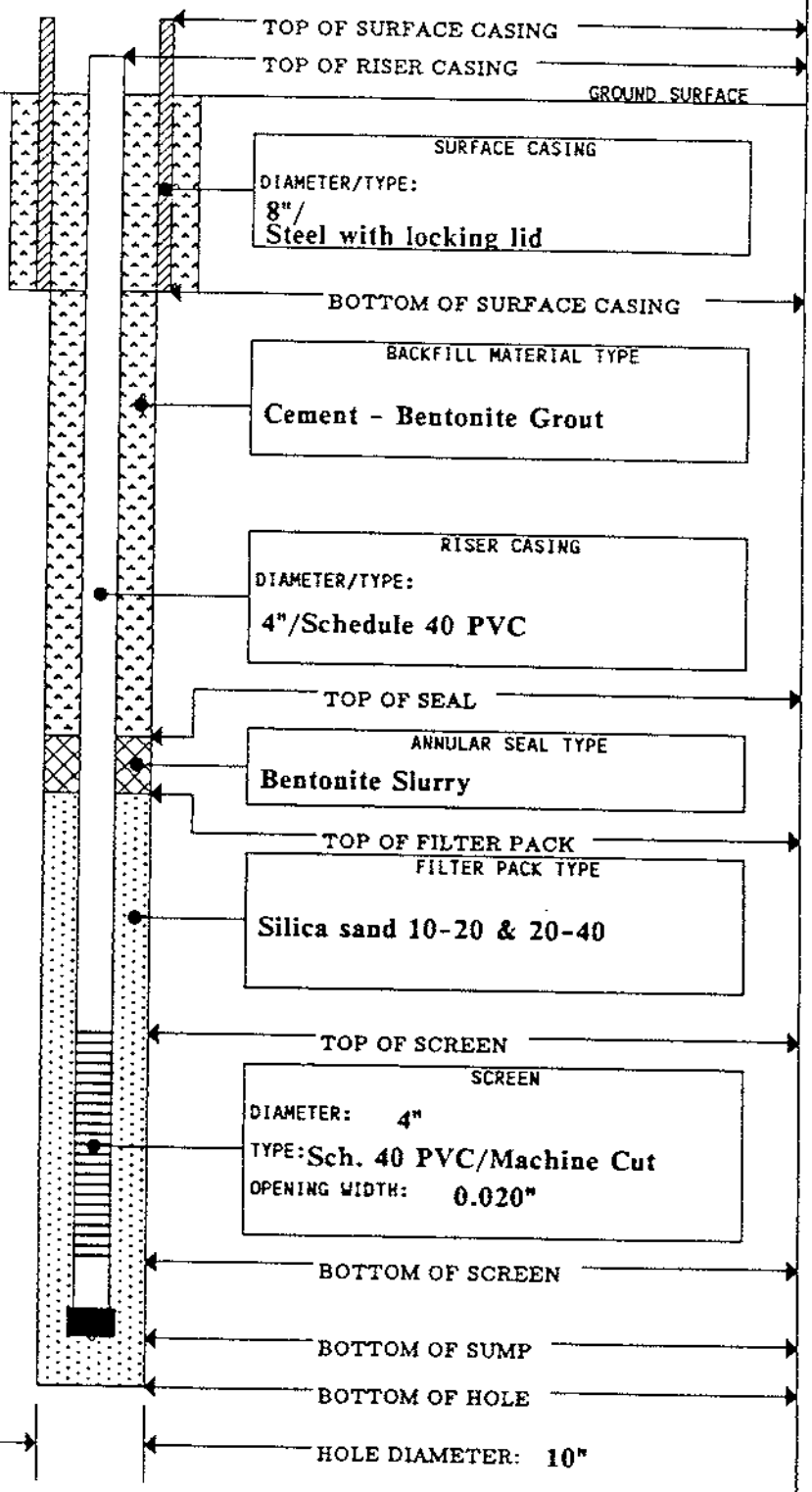
JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	Northern edge of site	N 452,890.2 E 556,296.9

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
10-11-90	10-12-90	Garrett Day	Top of PVC casing(Water level)

(GENERALIZED GEOLOGIC LOG)

See Boring Logs.

NOT TO SCALE



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.1	4468.4
TOP OF RISER CASING	1.7	4468.0
GROUND SURFACE	0.0	4466.3
BOTTOM OF SURFACE CASING	2.9	4463.4
TOP OF SEAL	84.0	4382.3
TOP OF FILTER PACK	88.0	4378.3
TOP OF SCREEN	92.3	4374.0
BOTTOM OF SCREEN	101.7	4364.6
BOTTOM OF SUMP	104.5	4361.8
BOTTOM OF HOLE	110.0	4356.3

Update: 8-12-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

PROJECT	WELL NO.
EMF POCATELLO, ID	134

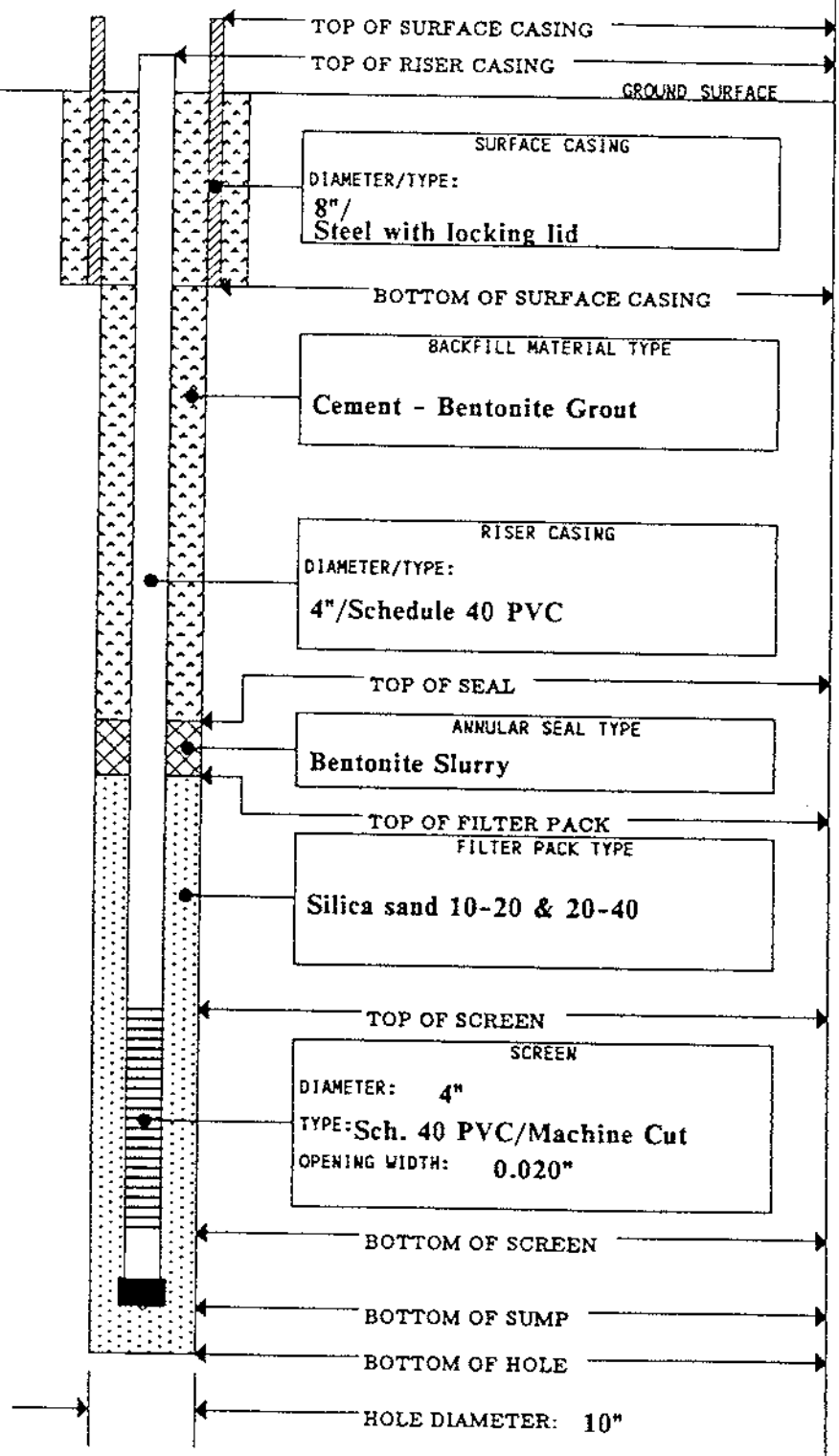
JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	North of former Pond 2S	N 451,636.8 E 555,354.2

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
10-29-90	10-29-90	Garrett Day	Top of PVC casing(Water level)

(GENERALIZED GEOLOGIC LOG)

See Boring Logs.

NOT TO SCALE



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.2	4479.2
TOP OF RISER CASING	1.9	4478.9
GROUND SURFACE	0.0	4477.0
BOTTOM OF SURFACE CASING	2.8	4474.2
TOP OF SEAL	94.0	4383.0
TOP OF FILTER PACK	98.0	4379.0
TOP OF SCREEN	102.5	4374.5
BOTTOM OF SCREEN	112.0	4365.0
BOTTOM OF SUMP	114.8	4362.2
BOTTOM OF HOLE	116.0	4361.0

Update: 8-12-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

PROJECT	WELL NO.
EMF POCATELLO, ID	139

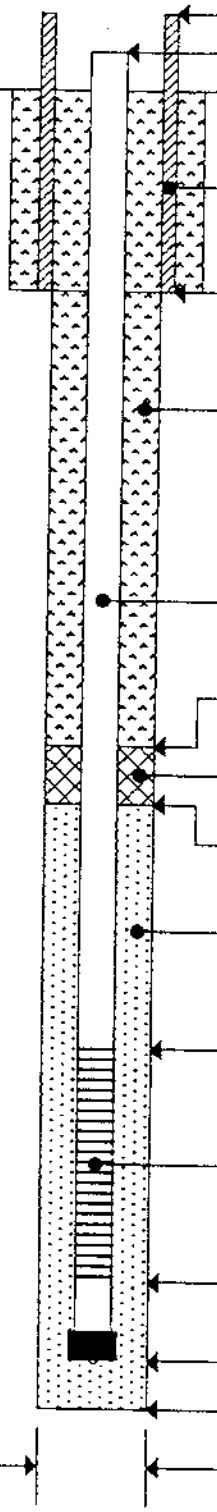
JOB NO.	SITE	COORDINATES and/or STATIONINGS
20906	FMC Corporation	N 450,368.1 E 553,167.0

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
5-13-92	5-13-92	Garrett Day	Top of PVC Casing-Water Level

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details

At 99-163 ft.: Backfill with C-B Grout



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	1.6	4467.9
TOP OF RISER CASING	1.4	4467.7
GROUND SURFACE	0.0	4466.3
BOTTOM OF SURFACE CASING	3.4	4462.9
TOP OF SEAL	78.0	4388.3
TOP OF FILTER PACK	83.0	4383.3
TOP OF SCREEN	88.4	4377.9
BOTTOM OF SCREEN	92.6	4373.7
BOTTOM OF SUMP	96.0	4370.3
BOTTOM OF HOLE	163.0	4303.3

SURFACE CASING
DIAMETER/TYPE: 8 1/2"/ Steel with Locking Lid

BACKFILL MATERIAL TYPE
Cement-Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Bentonite Slurry / Fine Sand

FILTER PACK TYPE
CSSI 10-20 Sand

SCREEN
DIAMETER: 4"
TYPE: Schedule 40 PVC
OPENING WIDTH: 0.020"

HOLE DIAMETER: 10"

Update: 7-28-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

PROJECT	WELL NO.
EMF POCATELLO, ID	145

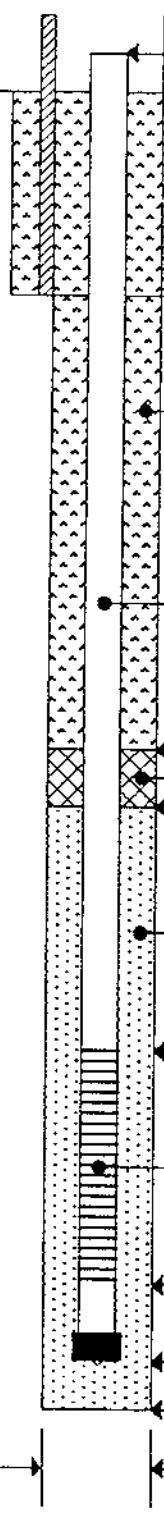
JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	FMC Corporation	N 452,188.7 E 557,552.3

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
4-30-92	5-5-92	H. Feng	Top of PVC Casing-Water Level

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details

At 143-150 ft.: Bentonite well plug



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	1.6	4478.6
TOP OF RISER CASING	1.3	4478.3
GROUND SURFACE	0.0	4477.0
BOTTOM OF SURFACE CASING	3.4	4473.6
TOP OF SEAL	120.0	4357.0
TOP OF FILTER PACK	122.0	4355.0
TOP OF SCREEN	130.0	4347.0
BOTTOM OF SCREEN	140.0	4337.0
BOTTOM OF SUMP	142.5	4334.5
BOTTOM OF HOLE	150.0	4327.0

SURFACE CASING
DIAMETER/TYPE: 8 1/2"/ Steel with Locking Lid

BACKFILL MATERIAL TYPE
Cement-Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Bentonite / Fine Sands

FILTER PACK TYPE
CSSI 10-20 Sand

SCREEN
DIAMETER: 4"
TYPE: Schedule 40 PVC
OPENING WIDTH: 0.020"

HOLE DIAMETER: 10"

Update: 11-10-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

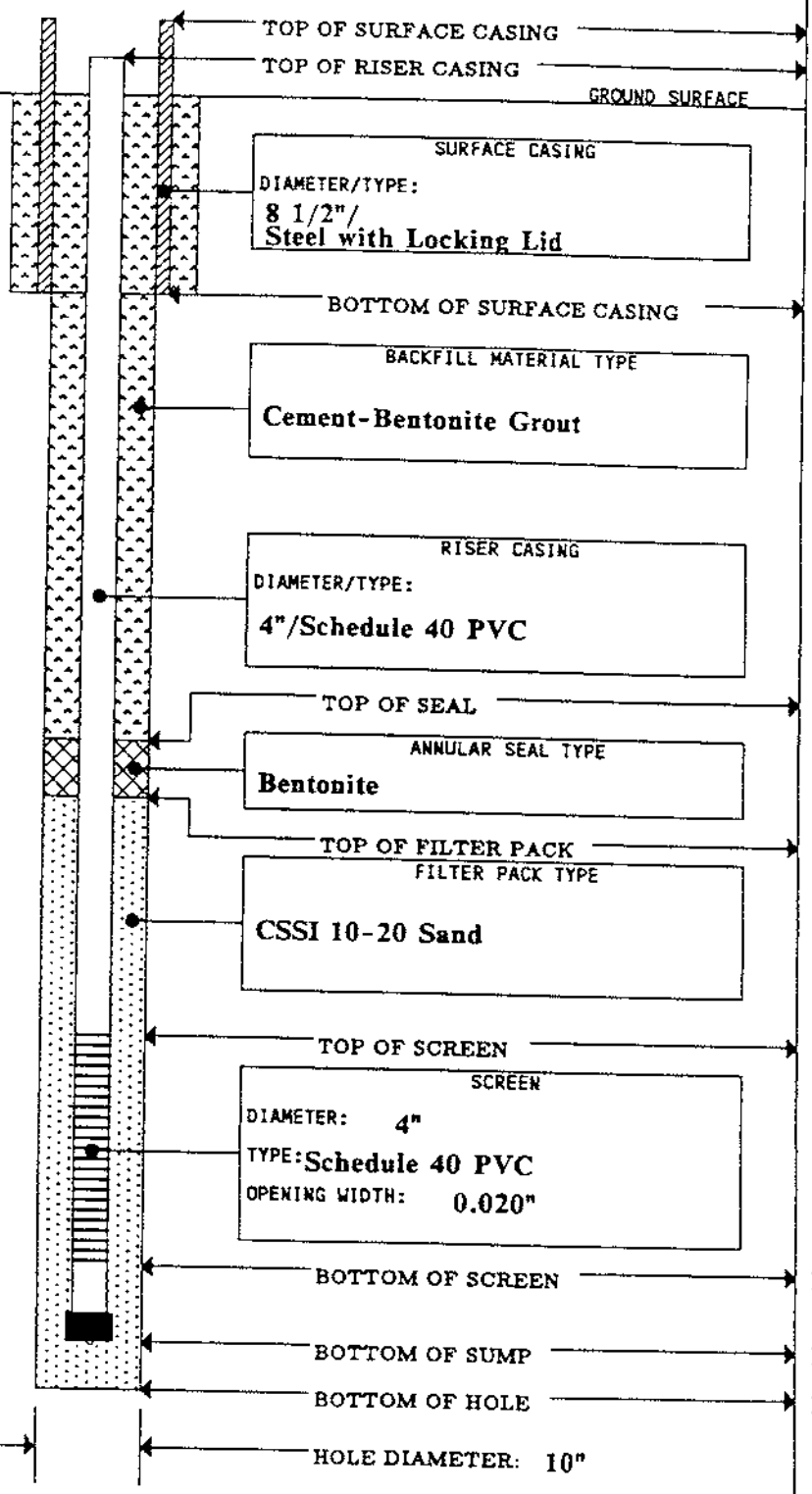
PROJECT	WELL NO.
EMF POCATELLO, ID	146

JOB NO.	SITE	COORDINATES and/or STATIONINGS
20906	FMC Corporation	N 453,214.1 E 557,382.2

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
4-21-92	4-22-92	H. Feng	Top of PVC Casing-Water Level

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.1	4460.0
TOP OF RISER CASING	1.4	4459.3
GROUND SURFACE	0.0	4457.9
BOTTOM OF SURFACE CASING	2.9	4455.0
TOP OF SEAL	76.5	4381.4
TOP OF FILTER PACK	81.5	4376.4
TOP OF SCREEN	90.0	4367.9
BOTTOM OF SCREEN	105.0	4352.9
BOTTOM OF SUMP	107.5	4350.4
BOTTOM OF HOLE	108.5	4349.4

HOLE DIAMETER: 10"

Update: 7-28-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

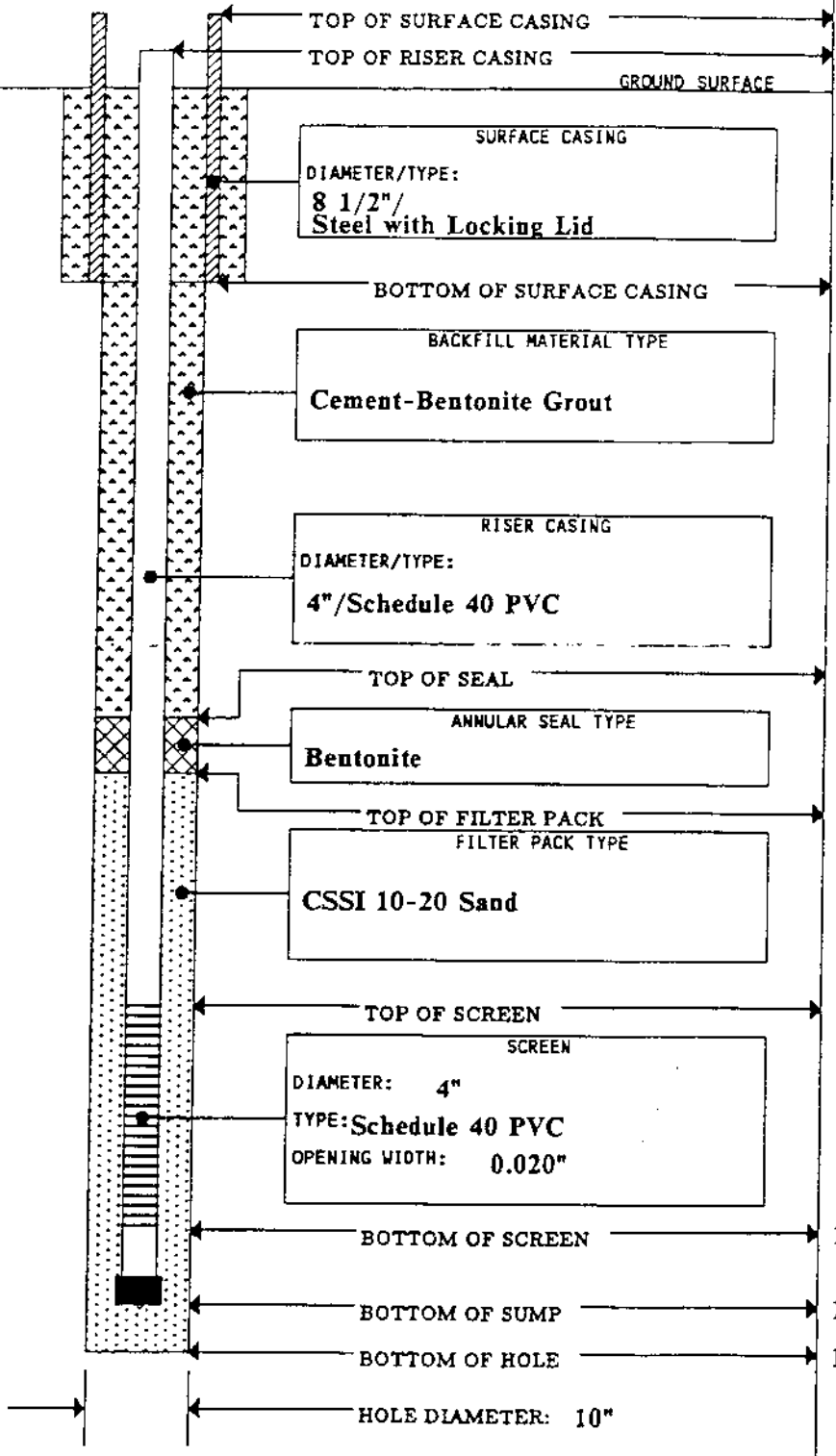
PROJECT	WELL NO.
EMF POCATELLO, ID	151

JOB NO.	SITE	COORDINATES and/or STATIONINGS
20906	FMC Corporation	N 450,773.5 E 555,023.3

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
4-24-92	4-26-92	H. Feng	Top of PVC Casing-Water Level

(GENERALIZED GEOLOGIC LOG)

See Geologic
Drill Log for Details



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	1.8	4501.7
TOP OF RISER CASING	1.5	4501.4
GROUND SURFACE	0.0	4499.9
BOTTOM OF SURFACE CASING	3.2	4496.7
TOP OF SEAL	114.0	4385.9
TOP OF FILTER PACK	119.0	4380.9
TOP OF SCREEN	125.0	4374.9
BOTTOM OF SCREEN	135.0	4364.9
BOTTOM OF SUMP	137.5	4362.4
BOTTOM OF HOLE	138.0	4361.9

Update: 7-28-92
Template: 2WELLOG

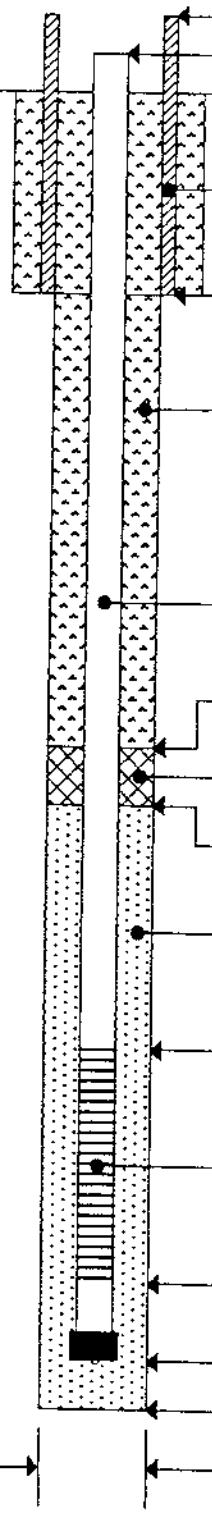
NOT TO SCALE

MONITORING WELL

PROJECT: *EMF POCATELLO, ID*			WELL NO. 159
JOB NO. 21372	SITE: FMC Corporation	COORDINATES and/or STATIONINGS: N 451,036.0 E 554,680.1	
BEGUN 6-26-93	COMPLETED 6-26-93	PREPARED BY: Dave Kyllonen	REFERENCE POINT FOR MEASUREMENTS: Top of PVC - Water levels

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.8	4494.6
TOP OF RISER CASING	2.0	4493.8
GROUND SURFACE	0.0	4490.0
BOTTOM OF SURFACE CASING	2.2	4479.6
TOP OF SEAL	100.0	4391.8
TOP OF FILTER PACK	105.0	4386.8
TOP OF SCREEN	110.5	4381.3
BOTTOM OF SCREEN	120.5	4371.3
BOTTOM OF SUMP	123.5	4368.3
BOTTOM OF HOLE	126.0	4364.0

SURFACE CASING
DIAMETER/TYPE: 8 5/8"/ Steel

BACKFILL MATERIAL TYPE
Cement-Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Bentonite Slurry

FILTER PACK TYPE
CSSI 10-20 Silica Sand

SCREEN
DIAMETER: 4"
TYPE: Schedule 40 PVC Slotted
OPENING WIDTH: 0.020"

HOLE DIAMETER: 10"

Update: 9-8-93
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

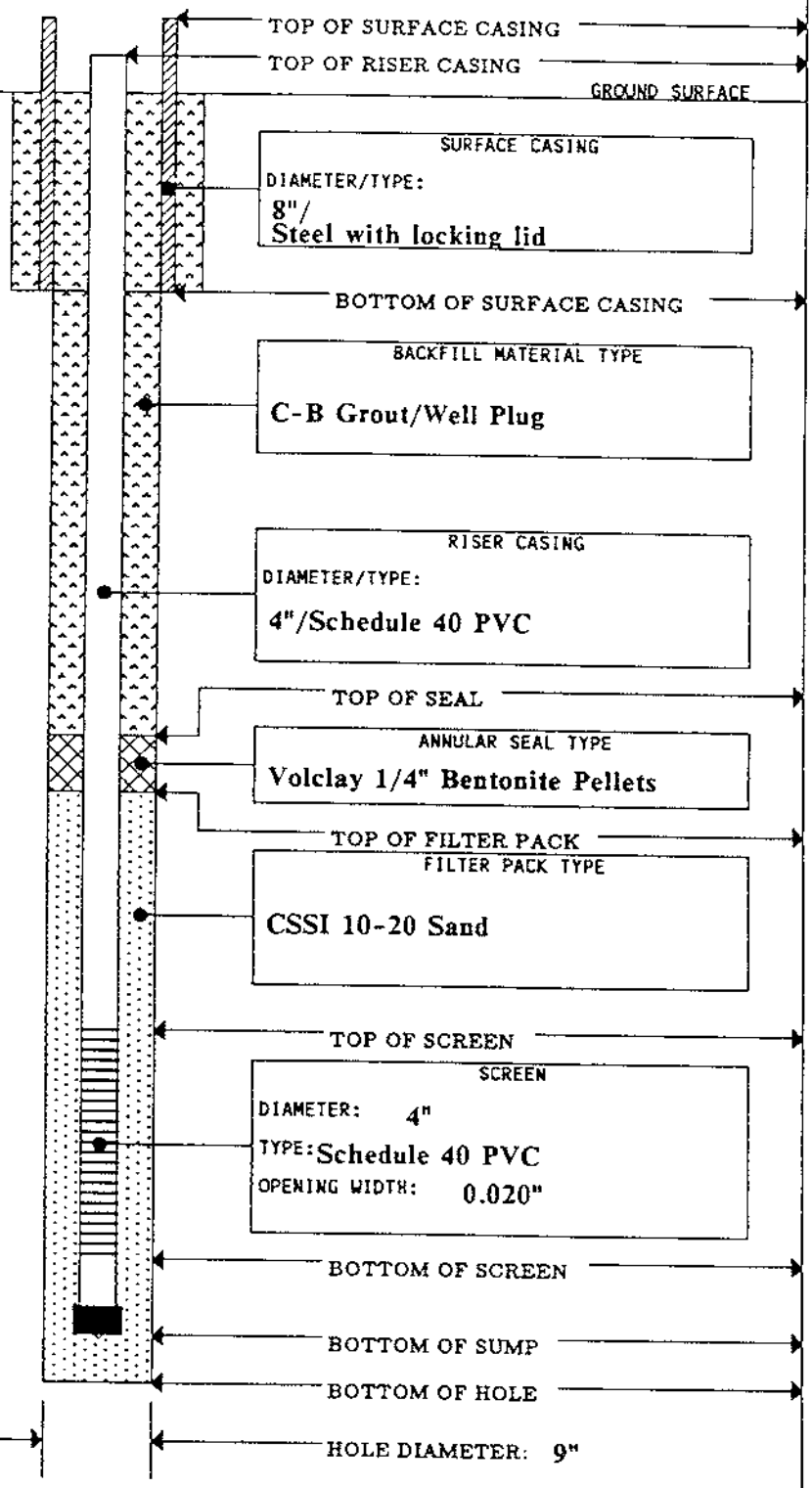
PROJECT	WELL NO.
EMF POCATELLO, ID	502

JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	North of Highway 30	N 454,363.3 E 558,079.5

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
5-18-92	5-19-92	D. B. McCullar	Top of PVC Casing-Water Level

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.5	4441.8
TOP OF RISER CASING	2.0	4441.3
GROUND SURFACE	0.0	4439.3
BOTTOM OF SURFACE CASING	3.5	4435.8
TOP OF SEAL	55.0	4384.3
TOP OF FILTER PACK	58.0	4381.3
TOP OF SCREEN	64.2	4375.1
BOTTOM OF SCREEN	69.2	4370.1
BOTTOM OF SUMP	72.0	4367.3
BOTTOM OF HOLE	74.0	4365.3

HOLE DIAMETER: 9"

Update: 11-11-92
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

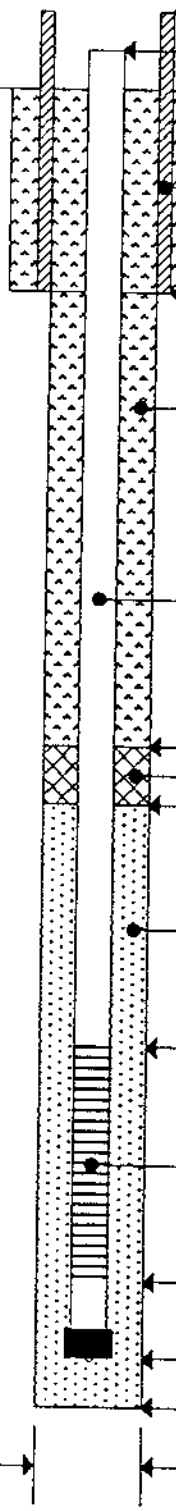
PROJECT	WELL NO.
EMF POCATELLO, ID	515

JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	Offsite	N 454,045.1 E 555,307.3

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
7-21-93	7-21-93	D. B. McCullar	Ground surface

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING		
TOP OF RISER CASING	0.3	4450.0
GROUND SURFACE	0.0	4450.3
BOTTOM OF SURFACE CASING	1.0	4449.3
TOP OF SEAL	63.0	4387.3
TOP OF FILTER PACK	67.0	4383.3
TOP OF SCREEN	71.2	4379.1
BOTTOM OF SCREEN	81.2	4369.1
BOTTOM OF SUMP	84.2	4366.1
BOTTOM OF HOLE	86.0	4364.3

SURFACE CASING
DIAMETER/TYPE: 8"/ Traffic rated steel

BACKFILL MATERIAL TYPE
Cement / Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Bentonite Slurry

FILTER PACK TYPE
CSSI 10/20 Medium Sand

SCREEN
DIAMETER: 4"
TYPE: Schedule 40 PVC - Machine cut
OPENING WIDTH: 0.020"

HOLE DIAMETER: 9 3/4"

Update: 10-4-93
Template: 2WELLOG

NOT TO SCALE

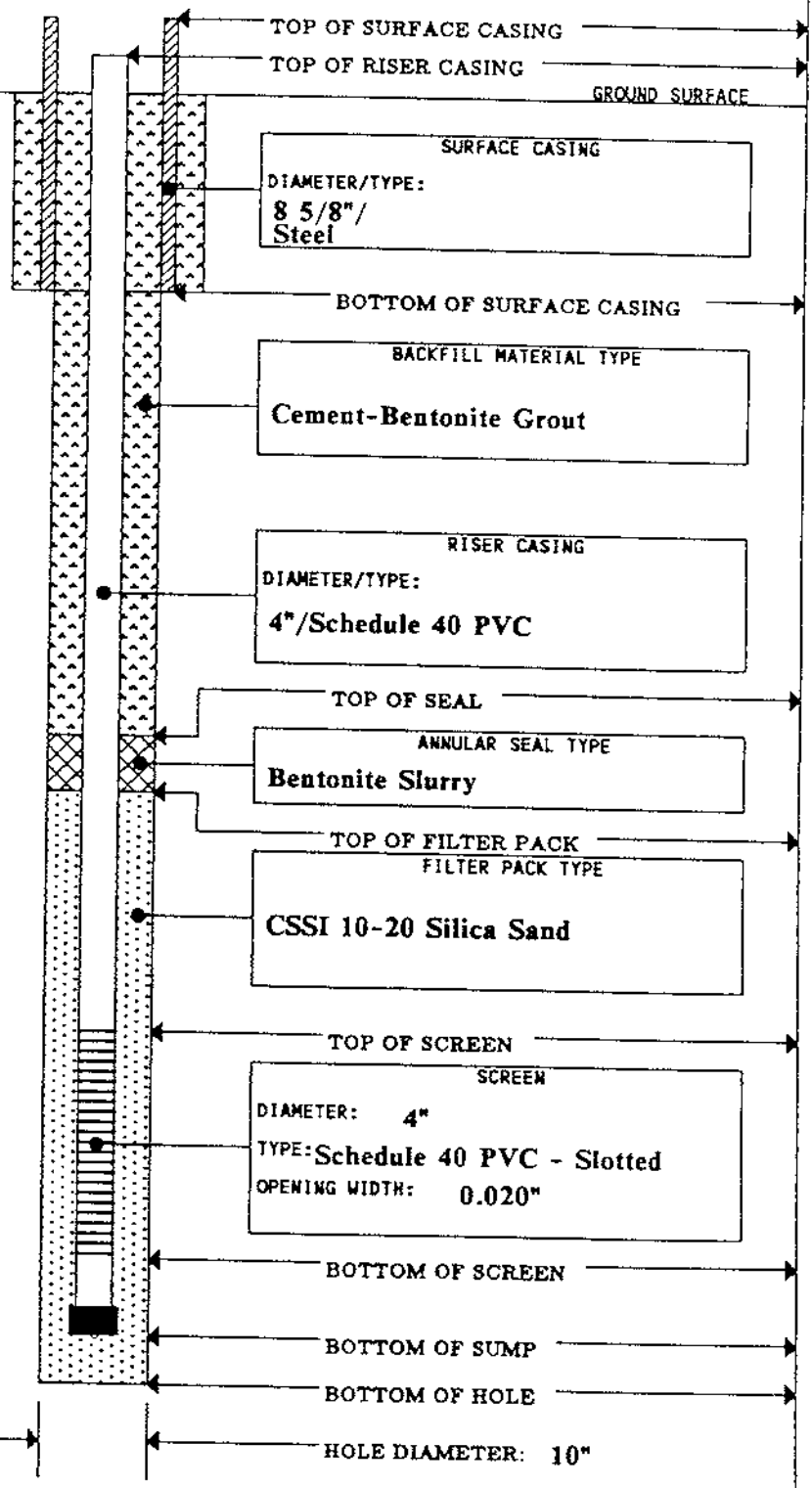
MONITORING WELL

PROJECT	WELL NO.
EMF POCATELLO, ID	517

JOB NO.	SITE	COORDINATES and/or STATIONINGS
21372	North of Highway 30	N 453,747.0 E 558,812.8

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
7-7-93	7-7-93	Dave Kyllonen	Top of PVC - Water levels

(GENERALIZED GEOLOGIC LOG)



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.7	4445.2
TOP OF RISER CASING	2.1	4444.6
GROUND SURFACE	0.0	4442.5
BOTTOM OF SURFACE CASING	3.3	4439.2
TOP OF SEAL	53.0	4389.5
TOP OF FILTER PACK	60.0	4382.5
TOP OF SCREEN	65.4	4377.1
BOTTOM OF SCREEN	75.4	4367.1
BOTTOM OF SUMP	78.4	4364.1
BOTTOM OF HOLE	79.5	4363.0

HOLE DIAMETER: 10"

Update: 8-19-93
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

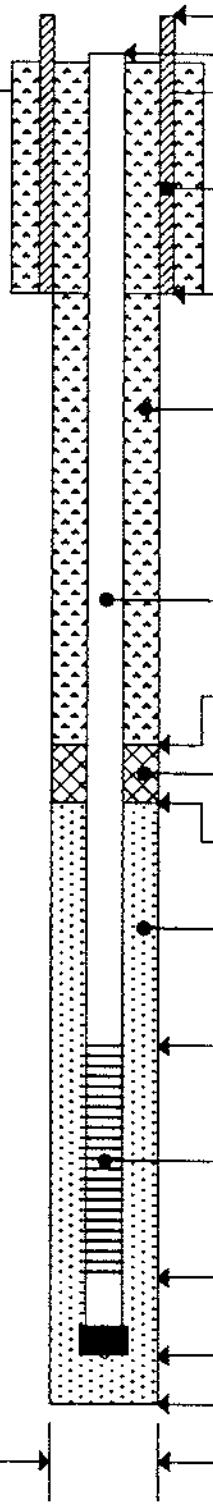
PROJECT	WELL NO.
EMF POCATELLO, ID	523

JOB NO.	SITE	COORDINATES and/or STATIONING
21372	OFF SITE	N 452,001 E 552,514

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
6-12-94	6-12-94	C. Obi	Notch at top of PVC: 4452.98'

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details.



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	3.0	4453.8
TOP OF RISER CASING	2.2	4453.0
GROUND SURFACE	0.0	4450.8
BOTTOM OF SURFACE CASING	2.0	4448.8
TOP OF SEAL	66.5	4384.3
TOP OF FILTER PACK	69.0	4381.8
TOP OF SCREEN	75.0	4375.8
BOTTOM OF SCREEN	85.0	4365.8
BOTTOM OF SUMP	85.5	4365.3
BOTTOM OF HOLE	90.0	4360.8

SURFACE CASING
DIAMETER/TYPE: 8"/ Steel Monument

BACKFILL MATERIAL TYPE
Cement-Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Enviroplug Bentonite Tablets

FILTER PACK TYPE
10-20 CSSI Silica Sand

SCREEN
DIAMETER: 4"
TYPE: Sch. 40 PVC Machine-Cut Slots
OPENING WIDTH: 0.020"

HOLE DIAMETER: 10"

Update: 7-11-94
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

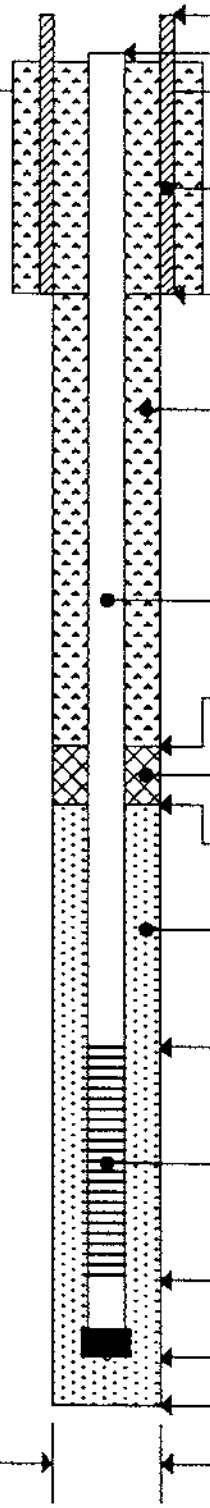
PROJECT	WELL NO.
EMF POCATELLO, ID	524

JOB NO.	SITE	COORDINATES and/or STATIONING
21372	OFF SITE	N 455,307 E 560,768

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
6-14-94	6-14-94	C. Obi	Notch at top of PVC: 4399.92'

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details.



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	3.0	4400.4
TOP OF RISER CASING	2.5	4399.9
GROUND SURFACE	0.0	4397.4
BOTTOM OF SURFACE CASING	2.0	4395.4
TOP OF SEAL	40.0	4.
TOP OF FILTER PACK	46.0	4351.4
TOP OF SCREEN	48.5	4348.9
BOTTOM OF SCREEN	58.5	4338.9
BOTTOM OF SUMP	59.0	4338.4
BOTTOM OF HOLE	122.0	4275.4

SURFACE CASING
DIAMETER/TYPE: 8"/ Steel Monument

BACKFILL MATERIAL TYPE
Cement-Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Bentonite Slurry / Fine Sand

FILTER PACK TYPE
10-20 CSSI Silica Sand

SCREEN
DIAMETER: 4"
TYPE: Sch. 40 PVC Machine-Cut Slots
OPENING WIDTH: 0.020"

HOLE DIAMETER: 10"

Update: 7-11-94
Template: 2WELLOG

NOT TO SCALE

MONITORING WELL

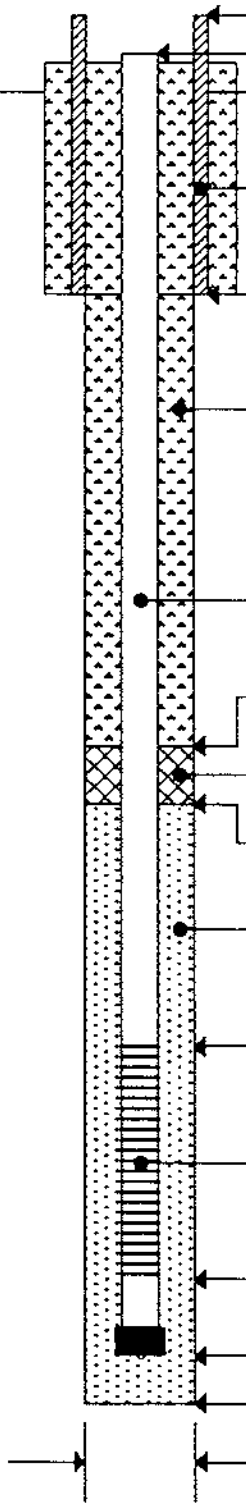
PROJECT	WELL NO.
EMF POCATELLO, ID	525

JOB NO.	SITE	COORDINATES and/or STATIONING
21372	OFF SITE	N 455,297 E 560,772

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
6-15-94	6-15-94	C. Obi	Notch at top of PVC: 4399.61'

(GENERALIZED GEOLOGIC LOG)

See Geologic Drill Log for Details.



	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.9	4400.0
TOP OF RISER CASING	2.5	4399.6
GROUND SURFACE	0.0	4397.1
BOTTOM OF SURFACE CASING	2.1	4395.0
TOP OF SEAL	3.0	4394.1
TOP OF FILTER PACK	15.5	4381.6
TOP OF SCREEN	17.8	4379.3
BOTTOM OF SCREEN	27.8	4369.3
BOTTOM OF SUMP	28.3	4368.8
BOTTOM OF HOLE	28.5	4368.6

SURFACE CASING
DIAMETER/TYPE: 8"/ Steel Monument

BACKFILL MATERIAL TYPE
Cement-Bentonite Grout

RISER CASING
DIAMETER/TYPE: 4"/Schedule 40 PVC

ANNULAR SEAL TYPE
Bentonite Tablets and Granules

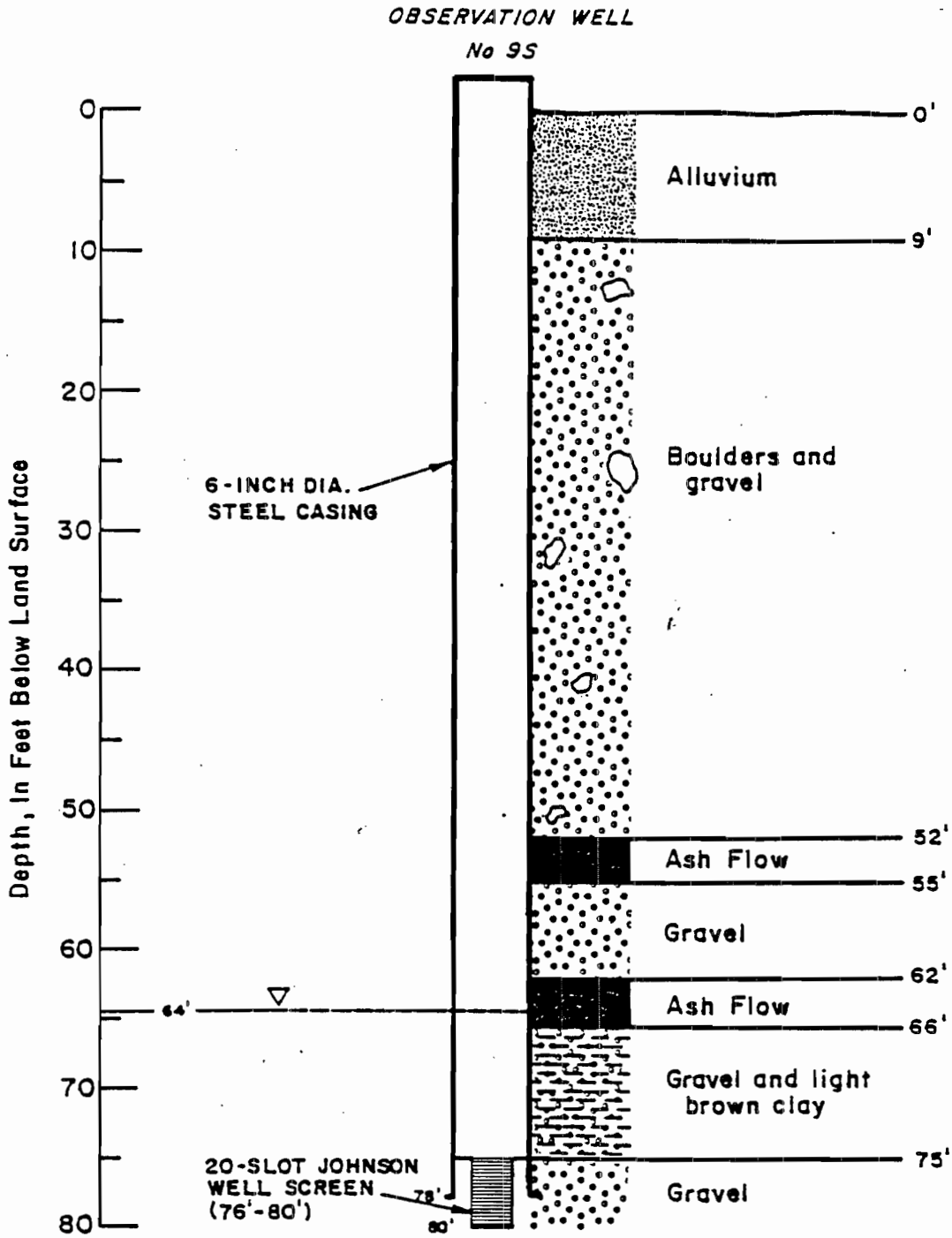
FILTER PACK TYPE
10-20 CSSI Silica Sand

SCREEN
DIAMETER: 4"
TYPE: Sch. 40 PVC Machine-Cut Slots
OPENING WIDTH: 0.020"

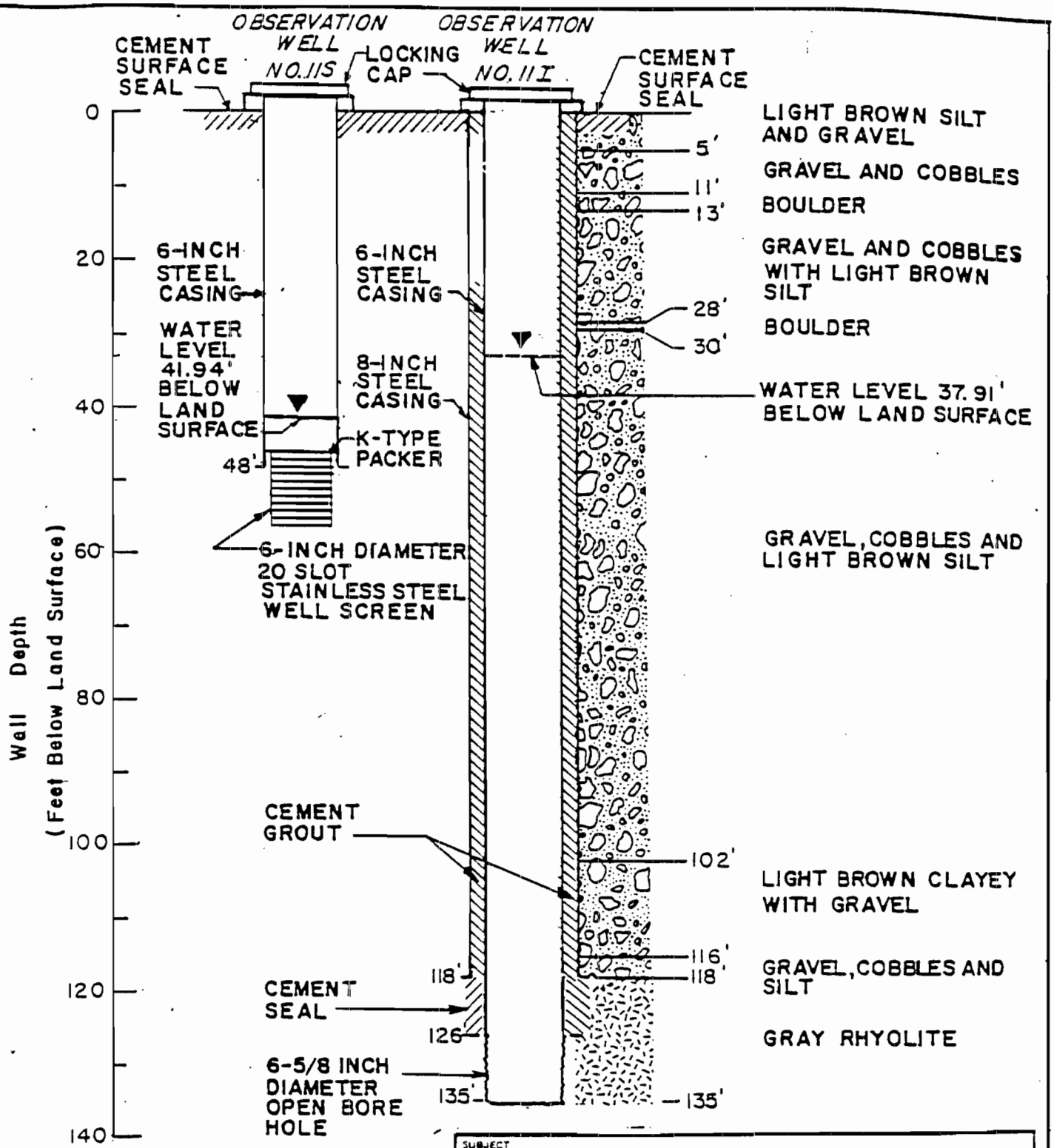
HOLE DIAMETER: 10"

Update: 7-11-94
Template: 2WELLOG

NOT TO SCALE



PREPARED FOR FMC CORPORATION POCATELLO, IDAHO		
TITLE WELL CONSTRUCTION DIAGRAM AND GEOLOGY OF SITE 9		
COMPILED BY Chris Creed	Geraghty & Miller, Inc. Syosset, N.Y	DATE 4/81
DRAWN BY C. Robertson		REVISED
CHECKED BY E. Koch	SCALE	Nº A-9



SUBJECT

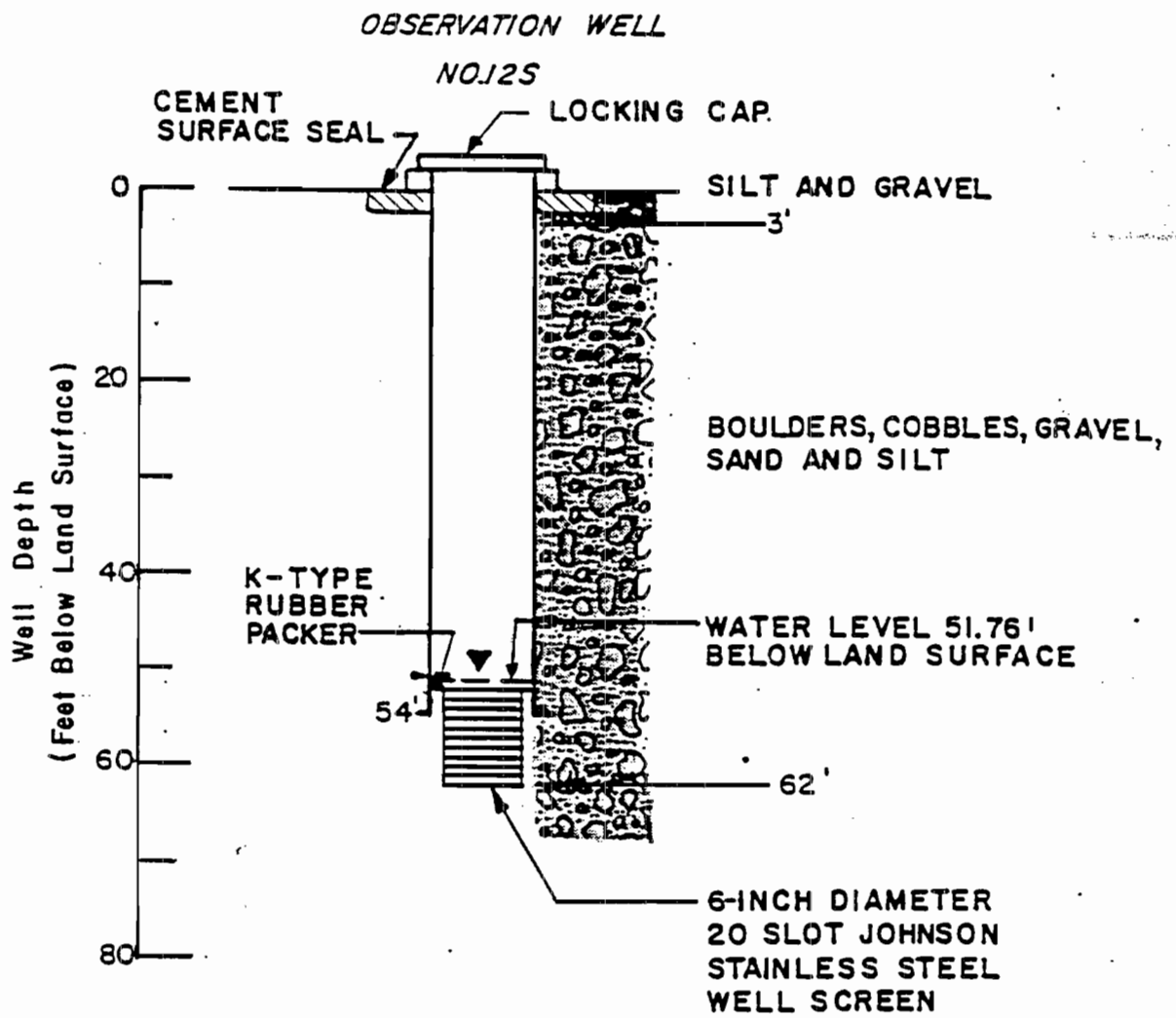
WELL CONSTRUCTION DIAGRAM AND GEOLOGY OF SITE 11

PREPARED FOR

FMC CORPORATION
POCATELLO, IDAHO

Geraghty & Miller, Inc.

COMPILED BY CHRISTOPHER CREED	SCALE SHOWN	FIGURE
PREPARED BY D. MONTANINO	DATE 3/82	A-11
PROJECT MGR ELLIS KOCH		



SUBJECT

WELL CONSTRUCTION DIAGRAM
AND GEOLOGY OF SITE 12

PREPARED FOR

FMC CORPORATION
POCATELLO, IDAHO

Geraghty & Miller, Inc.	COMPILED BY CHRISTOPHER CRECO	SCALE SHOWN	FIGURE A-12
	PREPARED BY D. MONTANINO	DATE 3/82	
	PROJECT MGR. ELLIS KOCH		

APPENDIX A-B

INTERIM CERCLA GROUNDWATER MONITORING PLAN

WELL COORDINATES AND MEASURING POINT ELEVATIONS

FMC Groundwater Monitoring Program
Monitoring Well Coordinates and Measuring Point Elevations

Location	Easting	Northing	"Top of Casing" Measuring Point Elevation *
101	551859.2	448838.9	4472.00
102	551848.4	448821.4	4471.68
103	554265.5	450122.5	4486.35
104	554270.2	450145.9	4486.71
106	556230.9	451116.9	4498.45
107	556591.1	452320.6	4482.46
108	556573.7	452316.5	4482.40
109	558357.7	453396.2	4451.31
110	558378.9	453398.7	4450.57
111	556296.9	452890.2	4468.04
112	554655.3	452105.6	4467.91
113	552482.1	449982.1	4467.93
114	553029.9	449848.7	4470.60
115	552938.2	449999.6	4469.73
116	554560	449931.2	4489.23
120	555064.5	450379.6	4500.32
121	556105.7	451766.8	4485.58
122	556282.4	452470.2	4475.92
123	557000.1	452221.3	4484.12
124	552028.7	450362.3	4448.45
125	552415.5	451221	4455.77
126	552429.6	451222.6	4455.97
127	552687.2	451067.8	4458.20
128	552683.9	450494	4461.85
130	552950.5	449329.3	4470.58
131	553742.7	450212	4485.95
133	555371.4	451641.8	4479.50
134	555354.2	451636.8	4478.93
135	555405.7	451154.5	4489.14
136	557882.9	451860.7	4479.55
137	552945.9	449345.5	4471.13
139	553167	450368.1	4467.66
140	554203.3	451119.7	4475.67
141	555009	451106.5	4493.89
142	557284.5	450017	4564.47
143	557172.8	451639	4496.31
144	557545.2	452188.1	4478.45
145	557552.3	452188.7	4478.26
146	557382.2	453214.1	4459.30

FMC Groundwater Monitoring Program
Monitoring Well Coordinates and Measuring Point Elevations

Location	Easting	Northing	"Top of Casing" Measuring Point Elevation *
147	550769.3	450622.8	4443.69
148	551187.8	450479.4	4446.45
149	551254.4	450047.3	4447.25
151	555023.3	450773.5	4501.42
154	550197.8	449702	4447.05
155	554398.54	450432.74	4491.21
156	554633.24	450418.57	4494.57
157	554874.47	450429.51	4502.30
158	554944.7	450027.9	4496.36
159	554680.1	451036	4491.79
161	558045.5	448320.6	4668.41
164	558064.3	449964.9	4588.09
165	551986.16	449237.25	4464.16
166	552801.98	450004.01	4469.77
167	554015.51	449404.11	4492.17
168	553285.94	450082.17	4473.94
169	550035.76	448217.19	4474.40
170	550967.58	449078	4452.40
171	551237.2	449596.49	4452.41
172	551080.8	449271.6	4450.57
173	550171.8	449231.3	4452.76
174	549303.4	449232.7	4447.12
175	549119	449797.1	4443.59
176	550019	450291.6	4443.29
177	550166.4	450022.2	4444.95
178	550275.2	449473.9	4451.14
179	550185.4	449247.5	4453.06
180	550976.2	449088.4	4452.77
181	551188.5	449666.4	4451.63
182	551105.4	449359.7	4449.92
183	554927.8	450017.7	4497.33
189	557824.5	451486.4	4560.72
190	557256.7	451000.4	4541.56
191	557404.48	449477.26	4579.85
501	554633	452767.7	4460.50
502	558079.5	454363.3	4441.30
503	560800.8	454363.7	4400.25
505	561200.5	454047.2	4395.71
514	553463.5	453442.7	4451.90

FMC Groundwater Monitoring Program
Monitoring Well Coordinates and Measuring Point Elevations

Location	Easting	Northing	"Top of Casing" Measuring Point Elevation *
515	555307.3	454045.1	4450.35
516	557119.4	454322.8	4445.50
517	558812.8	453747	4444.45
518	560470.7	453790	4417.15
523	552513.7	452001.4	4452.98
524	560768	455307	4399.92
525	560772.1	455296.9	4399.61
TW-11S	559985	454775	4426.24
TW-12S	559785	453975	4436.28
TW-5D	555985	452525	4475.00
TW-5I	555985	452525	4475.07
TW-5S	555985	452525	4475.15
TW-9S	557413.1	453819.7	4450.23
Springs			
BTS	560886	455155	4382.55
SWS	561034.6	454557.5	4384.53

* - Elevations are in Feet Above Mean Sea Level

BTS = Batiste Spring. Survey Pt is top of NE corner of concrete foundation for cistern. Reference Point Elev = top of steel flange on 'shroud' on overflow weir.

SWS = Swanson Road Spring (aka the Spring at Batiste Road). Survey and Measurement Pt is top of 7/8" rebar set near water level on west 'bank' and near north-south center of the spring basin.

ATTACHMENT B

INTERIM CERCLA GROUNDWATER MONITORING QUALITY ASSURANCE PROJECT PLAN

INTERIM CERCLA GROUNDWATER MONITORING QUALITY ASSURANCE PROJECT PLAN

Prepared for:

FMC Idaho, LLC

Pocatello, Idaho

JULY 2010

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INTERIM CERCLA GROUNDWATER MONITORING QUALITY ASSURANCE PROJECT PLAN

The Quality Assurance Project Plan (QAPP) describes the quality assurance and quality control requirements for the Interim CERCLA Groundwater Monitoring Program. These requirements have been established using the procedures recommended by EPA in *Quality Assurance Project Plans for Environmental Data Operations* (EPA, 2001). The QAPP has been prepared as Attachment B of the Interim CERCLA Groundwater Monitoring Plan (GMP) for the FMC site. QAPP requirements are implemented through the field sampling plan (FSP) presented in Attachment A of the GMP. The FSP provides the detailed field procedures that will be used to conduct groundwater monitoring.

This document is organized as follows: Section 1 presents project management information and requirements; Section 2 provides study design and implementation requirements ensuring that appropriate methods for sampling, analysis, data handling and quality control are employed and properly documented; Section 3 addresses the requirements for assessing the effectiveness of the quality control measures described in this plan; and Section 4 provides requirements for data validation and assurance of data usability.

1.0 PROJECT MANAGEMENT

1.1 PROJECT ORGANIZATION

The project organization is shown in Figure B-1. The responsibilities of key project personnel are as follows:

- FMC Project Manager - responsible for review, monitoring, auditing, and evaluation of performance of sampling and analytical contractors. Also responsible for assembly, organization and maintenance of all information collected during field activities. The FMC Project Manager has overall responsibility for all aspects of the groundwater monitoring program including reporting.

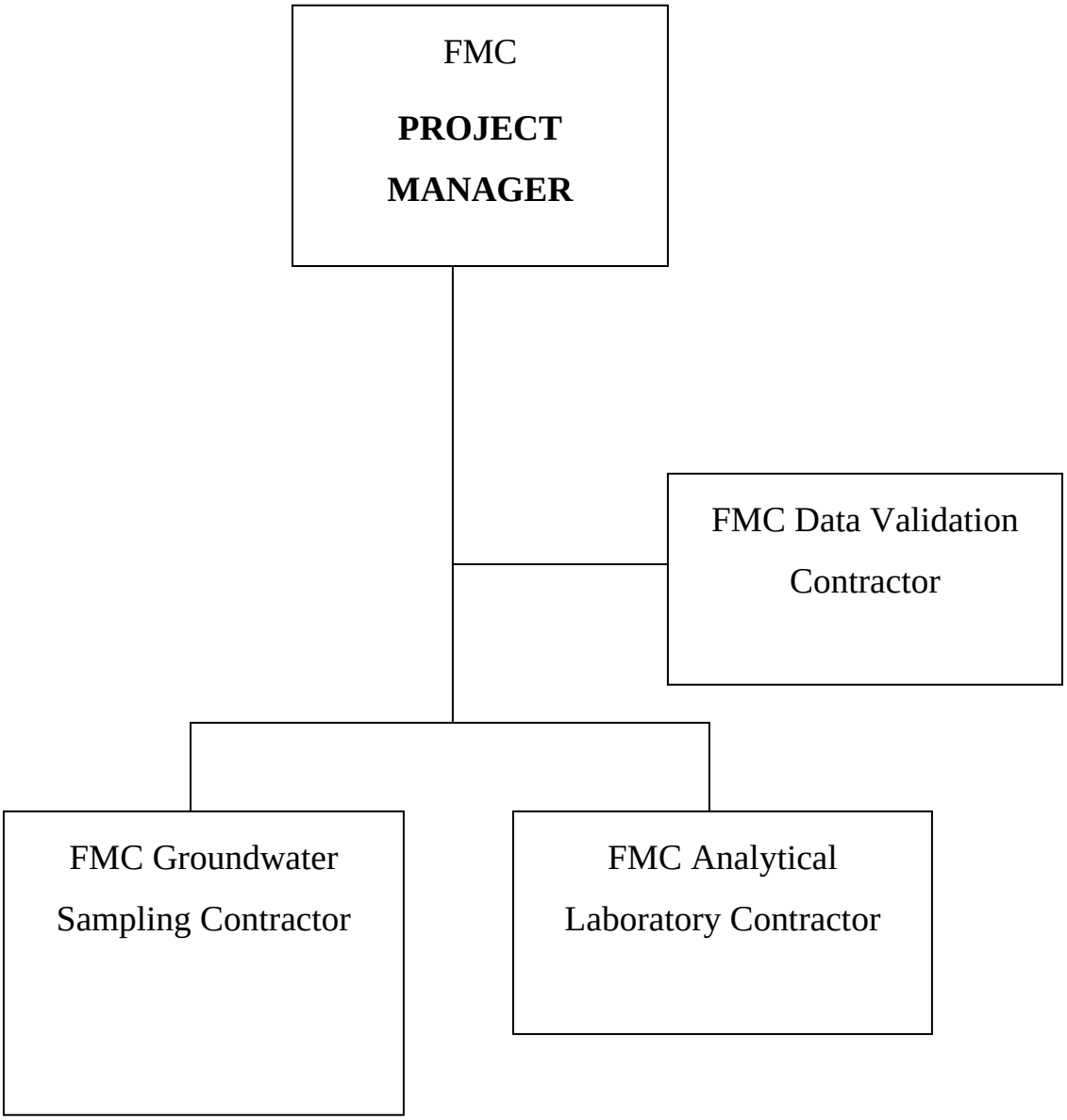
- FMC Groundwater Sampling Contractor - responsible for collection of samples in accordance with project guidance documents, the representativeness of samples collected, and reporting of field data relevant to groundwater monitoring and data management. Also responsible for maintenance of groundwater monitoring database.

- FMC Analytical Laboratory Contractor QA Officer - responsible for ensuring laboratory compliance with relevant provisions of the GMP/FSP/QAPP, and the accuracy and precision of data resulting from analysis of groundwater monitoring samples.

- FMC Data Validation Contractor - responsible for data validation.

All personnel are responsible for identifying problems that may arise in the collection and reporting of project data and overseeing the implementation of the necessary corrective actions. The FMC Project Manager will track, review, and verify the effectiveness of corrective actions.

FIGURE B-1. PROJECT ORGANIZATION



1.2 BACKGROUND

FMC has been conducting a voluntary CERCLA groundwater monitoring program in conjunction with its ongoing RCRA groundwater monitoring program and Calciner Pond Remedial Action groundwater monitoring program. The RCRA groundwater monitoring program began in 1991 at essentially the same time as the CERCLA Preliminary Site Characterization Study (PSCS) and Remedial Investigation (RI) groundwater investigations and monitoring. The Calciner Pond Remedial Action groundwater monitoring commenced during the second quarter of 2003 under the IDEQ-FMC voluntary consent order (VCO) for remedial action at the calciner ponds. FMC has been conducting its voluntary CERCLA groundwater monitoring program since the EMF Site ROD was issued in 1998. Due to the fact that a Remedial Design / Remedial Action (RD/RA) Consent Decree to implement the FMC Plant OU groundwater remedy, including the long-term groundwater monitoring specified in the 1998 ROD, was never entered, an EPA-approved CECLA groundwater monitoring plan has not been required nor prepared.

Following permanent shut-down of the FMC plant in December 2001, EPA and FMC entered into an AOC for a Supplemental Remedial Investigation and Feasibility Study SRI/SFS) at the FMC Plant Operable Unit (OU). Although the AOC and Statement of Work (SOW) for the FMC SRI/SFS did not require a supplemental groundwater investigation(s) at the FMC Plant OU, FMC recognizes the need to address groundwater (both EMF impacts identified during the EMF RI and the potential for future impacts) during the SFS for the FMC Plant OU. FMC prepared a Groundwater Current Conditions Report (GWCCR) for the FMC Plant OU as a compendium of the extensive EMF RI and post-RI groundwater investigations, results and evaluations to support the SFS for the FMC Plant OU. One of EPA's comments on the draft GWCCR was "FMC's voluntary CERCLA ground water monitoring program must make a transition as soon as possible into an interim ground water monitoring program that must be approved by EPA with the development of site specific DQO's. This interim program will continue until an amended ROD has been signed for FMC. Then a long-term ground water monitoring program will be developed once a remedy is selected."

During a series of EPA-FMC meetings during February, March and May 2009, FMC and EPA began moving forward toward development of both an interim and long-term CERCLA groundwater monitoring program for the FMC Plant OU. FMC recently finalized the *Groundwater Current Conditions Report* (GWCCR) *for the FMC Plant OU* (FMC, June 2009) and EPA approved the GWCCR by letter dated July 20, 2009. Consistent with EPA's direction, this interim CERCLA Groundwater Monitoring Plan is being submitted as an appendix to the SFS Report for the FMC Plant OU.

A detailed understanding of the sources, nature and extent of groundwater contamination is needed to effectively interpret monitoring results. The interim CERCLA groundwater monitoring plan provides a summary of the groundwater conditions at the site; however, the GWCCR provides a detailed description of the sources, nature and extent of groundwater contamination at the FMC Plant OU.

1.3 PROJECT DESCRIPTION

The interim CERCLA groundwater monitoring program wells to be sampled are listed in Table B-1. These wells will be sampled semi-annually and targeted for the fall (normally November) and spring (normally May) of each year.

TABLE B-1. INTERIM CERCLA PROGRAM MONITORING WELLS

Area	Well Numbers	Up / Downgradient [1]
On-Plant Site	134, 139, 151, 159, 145	D
Downgradient from Plant Site	111, 146, 110, TW-9S	D
Downgradient from FMC and Simplot Plant Sites	517, TW-12S	D
Northern Perimeter of EMF Groundwater Impact [2]	523, 515, 502, TW-11S, 524, 525	Cross

[1] Up / Downgradient refers to the wells hydrologic relationship to identified FMC and Simplot source areas.

[2] Impact is in reference to detection of arsenic, nitrate or selenium above representative levels.

1.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The overall objective of the groundwater monitoring program is to collect samples representative of the groundwater conditions at the FMC Plant OU. Data Quality Objectives for this groundwater-monitoring program are presented in Table B-2.

To meet these objectives, data of known quality will be collected and analyzed. To facilitate the required statistical analyses, discussed below, analytical methods with the lowest

TABLE B-2. DATA QUALITY OBJECTIVES FOR THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM

#	DQO Step	Data Quality Objectives
1	State the problem	An objective process is needed to evaluate groundwater flow patterns and potential changes and/or trends in site-related groundwater constituents on a FMC Plant OU-wide basis.
2	Identify the decision	Are concentrations of site-related groundwater constituents stable or decreasing in wells 1) downgradient from identified FMC source areas, 2) downgradient from the joint fenceline area and both EMF facility sites, and 3) along the northern perimeter and not site-impacted to date. If increasing concentration trends are identified, evaluate / identify likely cause and mitigation plan if related to FMC source(s).
3	Identify inputs to the decision	• FMC-Plant OU-wide groundwater elevation (water level) data. • Monitoring data from the interim CERCLA groundwater monitoring wells. • Results (output) from the annual assessments / evaluations specified under the RCRA and Calciner Pond Remedial Action groundwater monitoring programs annual reports.. • JR Simplot Company gypstack groundwater monitoring data will also be used to evaluate potential changes in flow patterns and source contributions in the joint fenceline area and downgradient from both EMF facility sites.
4	Define the study boundaries	**Spatial** • Downgradient of the FMC Plant Site groundwater impact source areas (as identified in the GWCCR and summarized in the Interim CERCLA Groundwater Monitoring Plan); • Downgradient of the FMC Plant Site and JR Simplot Plant Site in the area of EMF groundwater discharge to the Portneuf River between and including Swanson Road Spring (aka the Spring at Batiste Road) and Batiste Spring. • Cross-gradient wells to the northwest and northeast of the FMC Plant Site that have not previously / currently been impacted by FMC-impacts to groundwater. • Groundwater in the underlying uppermost aquifer zone. **Temporal** • EMF Remedial Investigation groundwater monitoring data (1991 to 1995). • FMC's on-going RCRA and Calciner Pond Remedial Action groundwater monitoring programs annual assessments. • FMC's post-RI voluntary and interim CERCLA groundwater monitoring program data (1996 to current). • JR Simplot Company gypstack groundwater monitoring data (currently reported quarterly and annually).

TABLE B-2. DATA QUALITY OBJECTIVES FOR THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM (CONTINUED)

#	DQO Step	Data Quality Objectives
5	Develop a decision rule	• Using the Mann-Kendall Trend Analysis, are there upward trends in arsenic, potassium, total phosphorus / orthophosphate, selenium and sulfate concentrations in samples collected from: o On-Plant Site wells: 134, 139, 151, 159 and 145 (in the joint fenceline area) o Plant Site downgradient wells: 111, 146, 110 and TW-9S o Wells downgradient from the FMC and Simplot Plant sites: 517 and TW-12S o Northern perimeter wells: 523, 515, 502, TW-11S, 524 and 525 • If so, are the upward trends attributable to EMF sources as follows: o On-Plant Site wells: Are trends at well 139, 134, 151 and/or 159 related to releases from the closed RCRA ponds, per RCRA annual assessment report, or are the changes more likely related to the former unlined phossy ponds in the western ponds area? Is trend at well 145 consistent with trends observed at the other wells in the joint fenceline area per annual Calciner Pond Remedial Action groundwater monitoring report? o Plant Site downgradient wells: Are trends at well 111 and/or 146 related to releases from the closed RCRA ponds or the closed RCRA slag pit sump, per RCRA annual assessment report, or are the changes more likely related to the former unlined phossy ponds in the western ponds area? Is trend at well 110 consistent with trends observed at the other wells in the joint fenceline area per annual Calciner Pond Remedial Action groundwater monitoring report? o Wells downgradient from the FMC and Simplot Plant sites: Are trends at well 517 and/or TW-12S related to releases from FMC sources, per annual RCRA and Calciner Pond groundwater reports, or are the changes more likely related to Simplot sources based on review of Simplot groundwater monitoring results? o Northern perimeter wells: Are trends related to undetected results at higher detection limit? If not, are results higher than relevant comparative value (CV) per Table 4-1 of the GMP? If so, are the trends consistent with trends observed at the nearest cross-gradient well(s) within the EMF-impacted area or are the changes more likely related to non-EMF sources? • If the upward trend(s) are attributable to the closed RCRA ponds or Calciner Pond Remedial Action, further evaluation and potential mitigation plan(s) will be performed under those programs. If the upward trend(s) are attributable to Simplot sources, Simplot retains responsibility for the performance of Simplot's remedial actions. If the upward trends are attributable to FMC source areas identified for CERCLA remedial action, ensure remedial design addresses mitigation of identified and potential future sources of groundwater impacts that could exceed the CVs (MCLs, secondary standards or RBCs).

TABLE B-2. DATA QUALITY OBJECTIVES FOR THE INTERIM CERCLA GROUNDWATER MONITORING PROGRAM (CONTINUED)

6	Specify limits on decision errors	The Mann-Kendall Trend Analysis will be performed at the 95% confidence level (i.e., $\alpha = 0.05$).
7	Optimize the design for obtaining data	Groundwater monitoring and data evaluation activities will be conducted as specified in the Interim CERCLA Groundwater Monitoring Plan, FSP and QAPP.

routinely achievable detection limits will be used. This will assure that the required statistical analyses are performed using as many positively detected values as possible.

The objective of the interim CERCLA groundwater monitoring program is to collect sufficient data of known quality to, in conjunction with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs, evaluate potential changes and/or trends in site-related groundwater constituents and evaluate groundwater conditions on an OU-wide basis. To meet this objective, groundwater samples from the monitoring wells listed in Table B-1 will be analyzed for the parameters specified in Table B-3 for the routine semiannual monitoring events and in Table B-4 for the expanded 5-year monitoring events. The acceptable level of uncertainty is included in Tables B-3 and B-4 as precision and accuracy goals. Samples will be handled in accordance with the requirements specified in the Field Sampling Plan and submitted for analysis in accordance with the requirements specified in Tables B-3 and B-4. Data generated from analysis of groundwater samples will be reviewed in accordance with the requirements specified in Section 4.

1.5 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

All personnel directly involved in sample collection, handling, analysis, and data evaluation will be provided with a copy of this QAPP and the applicable FSP. Personnel will be trained in the requirements specified herein, or provided ample time to read and become familiar with the requirements prior to beginning data collection activities.

1.6 DOCUMENTATION AND RECORDS

Records of the analyses and evaluations required by this plan will be maintained by FMC at the Pocatello plant or at another FMC corporate office. Laboratory documentation and records requirements are specified in the laboratory QAPP. Required field documentation is specified in the companion Field Sampling Plan. Data reporting requirements to EPA are specified in Section 5 of the Groundwater Monitoring Plan. All documentation and records for the Interim CERCLA Groundwater Monitoring Program (ICGMP) will be retained by FMC consistent with the records retention requirements under the Administrative Order on Consent for a Supplemental Remedial Investigation and Supplemental Feasibility Study for the FMC Plant OU, October 2003.

2.0 MEASUREMENT/DATA ACQUISITION

This section provides requirements for sampling program design, sample collection, handling, analysis, and data management. These requirements ensure that appropriate methods for sampling, analysis, data handling, and quality control are employed and documented.

TABLE B-3. SUMMARY OF REQUIRED ANALYSES

ROUTINE SEMIANNUAL GROUNDWATER MONITORING EVENTS

Parameter	Method Number	Method Type	Reporting Limit (mg/l)	Accuracy*	Precision**
Potassium	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.1	75% - 125%	± 30%
Chloride	9056 (b) or 325.3 (c)	Ion Chromatography or Titrimetric	1	75% - 125%	± 30%
Fluoride	9056 (b) or 340.2 (c)	Ion Chromatography or Potentiometric, Ion Selective Electrode	0.1	75% - 125%	± 30%
Arsenic, selenium	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.002 (As), 0.0005 (Se)	75% - 125%	± 30%
Nitrate	9056 (b) or 353.2 (d)	Ion Chromatography or Colorimetric	0.1	75% - 125%	± 35%
Total Phosphorus	6010B (a) or 365.2 (c)	Inductively Coupled Plasma / Mass Spectrometry or Colorimetric (ascorbic acid)	0.02	75% - 125%	± 30%
Sulfate	9056 (b) or 375.4 (d)	Ion Chromatography or Turbidimetric	1	75% - 125%	± 30%

(a) Analysis may also be performed using method 6020, both 6010 and 6020 from Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(b) Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(c) Methods for Chemical Analysis of Water and Wastes, EPA600/4–79–020, Revision, March 1983.

(d) Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100).

* percent recovery

** relative percent difference

TABLE B-4. SUMMARY OF REQUIRED ANALYSES
EXPANDED 5-YEAR GROUNDWATER MONITORING EVENTS

Parameter	Method Number	Method Type	Reporting Limit (mg/l)	Accuracy*	Precision**
Potassium	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.1	75% - 125%	± 30%
Chloride	9056 (b) or 325.3 (c)	Ion Chromatography or Titrimetric	1	75% - 125%	± 30%
Fluoride	9056 (b) or 340.2 (c)	Ion Chromatography or Potentiometric, Ion Selective Electrode	0.1	75% - 125%	± 30%
Arsenic, selenium, manganese, boron and vanadium	6010B (a)	Inductively Coupled Plasma Atomic Emission Spectrometry	0.002 (As), 0.0005 (Se), 0.0006 (Mn), 0.018 (B), 0.002 (V)	75% - 125%	± 30%
Nitrate	9056 (b) or 353.2 (d)	Ion Chromatography or Colorimetric	0.1	75% - 125%	± 35%
Total Phosphorus	6010B (a) or 365.2 (c)	Inductively Coupled Plasma / Mass Spectrometry or Colorimetric (ascorbic acid)	0.02	75% - 125%	± 30%
Sulfate	9056 (b) or 375.4 (d)	Ion Chromatography or Turbidimetric	1	75% - 125%	± 30%
Total Ammonia (NH_3 + NH_4 as N)	350.3 (d)	Potentiometric, Ion Selective Electrode	0.2	75% - 125%	± 30%
Total Cyanide	335.4 (d)	Colorimetric	0.01	75% - 125%	± 30%

(a) Analysis may also be performed using method 6020, both 6010 and 6020 from Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(b) Test Methods for Evaluating Solid Waste, EPA SW–846, Third Edition, Update IIIB, as revised through 2002.

(c) Methods for Chemical Analysis of Water and Wastes, EPA600/4–79–020, Revision, March 1983.

(d) Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100).

* percent recovery

** relative percent difference

2.1 SAMPLING METHODS REQUIREMENTS

The groundwater monitoring wells associated with the Interim CERCLA Groundwater Monitoring Plan will be sampled in accordance with the detailed procedures presented in the FSP (Attachment A to the Groundwater Monitoring Plan).

2.2 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

The groundwater samples will be handled and custody will be maintained in accordance with the detailed procedures presented in the FSP.

2.3 ANALYTICAL METHODS REQUIREMENTS

The analytical methods that will be used on groundwater monitoring samples are summarized in Tables B-3 and B-4. The tables specify the method number, method type, and method detection limit ranges. Reporting limits presented on Tables B-3 and B-4 for each analysis represent the best reporting limits that can be attained by the specified methodology. Data from multiple dilutions will be used, as necessary, to quantify target components within the calibrated range. Actual reporting and detection limits obtained during analysis will be reported by the laboratory for each parameter in each sample.

The laboratory performing the analyses will have an established quality assurance/quality control (QA/QC) plan and all analyses will be performed in accordance standard operating procedures consistent with the QA/QC plan. Where analytical or QA/QC procedures presented in the QAPP are different from those presented in the laboratory QA/QC plan, procedures presented in this QAPP will govern.

2.4 QUALITY CONTROL REQUIREMENTS

Both field and laboratory QC checks will be employed to evaluate field contamination, the variability of field techniques and the performance of laboratory analytical procedures. QC checks will take the form of samples introduced into the analytical stream to enable evaluation of sampling and analytical accuracy and precision. Such QC samples will be regularly prepared in the field and laboratory so that all phases of the sampling process are monitored.

The well sampling schedule for the Interim CERCLA groundwater monitoring program will be coordinated with FMC's Calciner Pond Remedial Action groundwater monitoring, which includes similar analytical requirements. This will enable concurrent collection of field duplicates and samples used to evaluate sampling and analytical quality, as noted below.

2.4.1 Field Quality Control Samples

Field Duplicates - Field duplicate samples will be collected for use as a measure of the precision of the sample collection and analysis process. The duplicate will be submitted with minimal indication of the site it was taken from. Duplicates will be prepared following standard sampling and preparation techniques as described in the FSP and submitted to the laboratory at a minimum frequency of one per sample delivery group or every 20 samples.

Rinsate Blanks - Rinsate blanks are collected by pouring reagent grade purified water over or through submersible pump setups to evaluate the effectiveness of field decontamination of sampling equipment. The blank is analyzed for the same analytical parameters as the groundwater samples. Rinsate blanks will be collected after decontamination and at a minimum frequency of one per sample delivery group or every 20 samples.

Distilled or De-ionized Water Blank – Distilled or de-ionized water blanks are aliquots of water collected directly from the field supply container and analyzed to determine distilled / de-ionized water quality. The blanks are collected at a frequency of one per semi-annual sampling event and are analyzed for the same parameters as the groundwater samples. The distilled or de-ionized blanks are collected in conjunction with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs (i.e., one distilled or de-ionized water blank per sampling event concurrently satisfies requirement for all three monitoring programs).

2.4.2 Matrix Spike / Matrix Spike Duplicate Quality Control Samples

Matrix spike / matrix spike duplicate (MS/MSD) quality control samples will also be collected at a frequency of one per sample delivery group or one per twenty samples collected. The well designated for a MS/MSD quality control sample will be randomly selected during each monitoring event from one of the sixteen interim CERCLA program monitoring wells.

2.4.3 Laboratory QA/QC Samples

Laboratory QC samples consist of laboratory method blanks, laboratory control samples, matrix spike, and laboratory duplicates or matrix spike duplicates. Requirements for laboratory QC samples are specified in the Laboratory's Quality Assurance Project Plan.

For method-specific QC criteria and samples (e.g. calibration blanks or initial calibrations), the criteria specified in the methods will be used. The methods will be performed as written. Any deviations, if allowed, must be approved by the FMC Environmental Manager in writing prior to implementation by the laboratory. Procedures will be in place for demonstrating that the laboratory is in control during each analytical measurement.

Laboratory Control Samples - The laboratory will be considered in control when data generated by analysis of control samples fall within laboratory prescribed limits. Data generated by analysis of control samples that falls outside the established control limits are judged to be generated during an "out-of-control" situation. These data are considered suspect and shall be repeated or reported with qualifiers. Laboratory control samples shall be analyzed for each analytical method when appropriate for the method. A laboratory control sample consists of either a control matrix spiked with the analytes of interest for this program or a certified reference material that contains the analytes of interest. Laboratory control sample(s) shall be analyzed with each batch of samples processed to verify that the precision and bias of the analytical process are within control limits. The results of the laboratory

control sample(s) will be compared to control limits established by the laboratory for both precision and bias to determine usability of the data.

Method Blank - A method blank shall be analyzed with each batch of samples processed to assess contamination levels in the laboratory. The laboratory shall have guidelines in place for accepting or rejecting data based on the level of contamination in the blank. For a method blank to be acceptable for use with the accompanying samples, the concentration in the blank of any analyte of concern shall not be higher than the highest of either:

- The MDL, or
- Five percent of the regulatory limit for that analyte, or
- Five percent of the measured concentration in the sample.

Matrix Spike/Matrix Spike Duplicates for Matrix Duplicate Samples - Procedures shall be in place for documenting the effect of the matrix on method performance. When appropriate for the method, there shall be at least one matrix spike (MS) and either one matrix duplicate (MD) or one matrix spike duplicate (MSD) per analytical batch. These procedures shall include preparation and analysis of matrix spikes and the method of standard additions for metal and inorganic methods. When the concentration of the analyte in the sample is greater than 0.1% (1,000 ppm), no spike is necessary. Procedures shall be in place for determining the precision of the method for a specific matrix. These procedures shall include analysis of matrix duplicates and/or matrix spike duplicates.

If the concentration of a specific analyte in the sample is being checked against a regulatory concentration limit or action level, the spike shall be at or below the limit, or 10 times the background concentration (if historical data are available), whichever concentration is higher.

If the concentration of a specific analyte in a sample is not being checked against a limit specific for that analyte, then the analyst may spike the sample at the same concentration as the reference sample, at 20 times the estimated quantitation limit (EQL) in the matrix of interest, or at a concentration near the middle of the calibration range.

2.5 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

All equipment used in the conduct of this work will receive routine maintenance checks in order to minimize equipment breakdowns. Maintenance checks will generally coincide with calibration checks. Any equipment found to be operating improperly will be taken out of use, and a notation stating the time and date of this action will be made in a log book. The equipment will be repaired, replaced or recalibrated, as necessary, and the time and date of its return to service will also be recorded. Groundwater monitoring equipment will be inspected and maintained as noted in Table B-5.

TABLE B-5. GROUNDWATER MONITORING EQUIPMENT INSPECTION AND MAINTENANCE ACTIVITIES

Inspection Item	Inspection Frequency	Maintenance Action
Field equipment	Semiannual	Repair or replace defective/damaged equipment
Laboratory equipment	Semiannual	Recalibrate; repair or replace defective equipment in accordance with Laboratory QA/QC Plan

2.6 INSTRUMENT CALIBRATION AND FREQUENCY

The requirements in this section pertain to the calibration of field equipment. Laboratory equipment will be calibrated in accordance with an established QA/QC plan and all calibrations will be performed in accordance standard operating procedures consistent with the QA/QC plan. Additional requirements related to laboratory instrument calibrations and frequency requirements are specified in the laboratory QA/QC plan. All calibrations of field equipment will be recorded in appropriate logbooks. Table B-6 provides a summary of field equipment calibration requirements.

TABLE B-6. SUMMARY OF FIELD EQUIPMENT CALIBRATION REQUIREMENTS

Field Parameter	Instrument / Method	Calibration	Calibration Frequency	Estimated Accuracy*
Water Level Survey	Electrical Water Probe Steel Tape	Reference to Steel Tape Reference to New Tape	Periodically Periodically	0.1 ft 0.01 ft
Specific Conductance	Conductivity meter	Daily, single standard (typically 1413 µmhos/cm)	Daily	± 0.5% or 1 µmhos/cm
Dissolved Oxygen	Dissolved oxygen meter	Daily, based on local barometric pressure and water-saturated air	Daily	± 2% or 0.2 mg/L
ORP	ORP meter	Daily, using ORP buffer solution; solution temperature must also be recorded	Daily	± 20 mV
Temperature	Temperature meter	Factory calibration only	Factory only	0.15 °C
Nephelometric turbidity (NTU)	Turbidity meter	Daily, check against 2 known standards	Daily	± 2%
pH	pH meter	Daily, 2- or 3-point with standard buffers (4, 7, 10)	Daily	± 0.2 pH unit

*Based on manufacturer specifications for YSI 556 MPS system and HACH 2100P turbidity meter currently used for FMC groundwater monitoring. Alternate instrumentation should have comparable estimated accuracies.

2.7 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

Groundwater sample containers will be new or pre-cleaned and supplied by the laboratory performing sample analysis along with any required preservatives. All other consumables will be decontaminated prior to use in accordance with the equipment decontamination procedure presented in the FSP.

2.8 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

To meet groundwater-monitoring objectives at the FMC Facility, no data from non-direct measurements are required, other than that collected during groundwater sampling and sample analysis.

2.9 DATA MANAGEMENT

Data from both the field and the laboratory will be managed during this project. Field data will consist of field notebooks, field sampling forms, daily calibration forms, and chain of custody forms. Sampling forms, calibration forms, and chain of custody forms will be retained by the groundwater-sampling contractor until the end of each semiannual sampling event, then forwarded to the FMC Project Manager for retention. Original field notebooks will be maintained by the sampling contractor, with copies provided to the FMC Project Manager on a semiannual basis.

The laboratory documentation required for each sample delivery group depends on the anticipated level of review. The documentation requirements of data validation and data review are presented below. The Groundwater Sampling Contractor will maintain the analytical database.

<u>Laboratory Documentation for Data Validation</u>

The following documentation will be provided by the laboratory for each sample delivery group scheduled for validation:

1. Case Narrative
2. Chain of Custody Documentation
3. Summary of Results
4. QA/QC Result Summaries
5. Raw Data.

The format and detailed content of the laboratory documents will support validation of the data in accordance with *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, July 2002). An electronic data deliverable will be provided by the laboratory in a file format specified by FMC that is compatible with Excel, Access, or dBase III software. The deliverable will contain the fields specified in Table B-7. Data packages for full validation will be forwarded by the laboratory to the data validation

contractor. At the same time, a copy of items 1 through 4 will be forwarded to the FMC Project Manager for retention.

Laboratory Documentation for Data Review

Each sample delivery group of laboratory data not planned for validation will include items 1 through 4 described above in the same level of detail as required if the data were to be validated. Item 5, Raw Data, is not required. An electronic data deliverable will be provided by the laboratory in a file format specified by FMC. The deliverable will contain the fields specified in Table B-7. Items 1 though 4 will be forwarded to the FMC Project Manager for retention.

TABLE B-7. DATABASE FIELD ACRONYMS AND DESCRIPTIONS

DATABASE FIELD NAME	Type	Size	FULL NAME	DESCRIPTION
STA_ID	Text	12	Station ID:	well number, etc. (i.e., F308300 or S308108)
AGENCY	Text	8	Agency	investigating party (EPA)
SAMP_DATE	Date/Time	8	Sample Date	date sample was taken
SAMP_ID	Text	8	Sample ID	unique identification number given to each sample
WTR_DEP	Number (Double)	8	Water Depth	depth to where water is found from casing reference notch (in ft.)
WTR_ELEV	Number (Double)	8	Water Elevation	elevation above mean sea level of groundwater (in ft.)
CHEM_NAME	Text	36	Chemical Name	name of chemical
CAS_NO	Text	12	Chemical Abstract Service Number	number that is given to identify a unique chemical by the Chemical Abstract Service
CONC_DET	Number (Double)	8	Concentration Detection	chemical concentration that was detected
QUAL	Text	4	Qualifier	laboratory qualifier given to each sample
UNITS	Text	12	Units	units of measurement
QUAL_VAL	Text	4	Validation Qualifier	qualifier assigned as a result of data validation
QUAL_CODE	Text	6	Code Qualifier	code used by validation to indicate why a qualifier was assigned
VAL_LVL	Text	4	Validation Level	level or extent of validation done
CHEM_NO	Number (Double)	8	Chemical Number	chemical number given by FMC for database sorting

TABLE B-7. DATABASE FIELD ACRONYMS AND DESCRIPTIONS (CONTINUED)

DATABASE FIELD NAME	Type	Size	FULL NAME	DESCRIPTION
SAMP_TYPE	Text	4	Sample Type	e.g., groundwater (GW), surface water (SW) or potential source (PS) sample
LAB_NAME	Text	12	Laboratory Name	name of laboratory that performed the analyses
LAB_ID	Text	12	Laboratory Identification	identification number given to a sample by laboratory
QUAL_ANAL	Text	4	Analysis Qualifier	lab-assigned qualifier (see Qualifier Description)
QUAL_SAM	Text	8	Qualifying Sample	sample qualifier indicating that sample is not representative (see Qualifier Description)
AN_DATE	Date/Time	8	Analytical Date	date sample was analyzed for constituents
AN_METHOD	Text	20	Analytical Method	method used for analyzing chemicals
PKG_NAME	Text	9	Package Name	laboratory sample delivery group (SDG)
ACTUAL_VAL	Number (Double)	8	Actual Value	actual value shown for accuracy, used only for radiological
ACCURACY	Number (Double)	8	Accuracy	± accuracy (for rad samples)
RPT_LIM	Number (Double)	8	Reporting Limit	laboratory required reporting limit
FILE_NAME	Text	8	File Name	chronological name of an event

3.0 ASSESSMENT/OVERSIGHT

Periodic surveillance of sampling activities will be conducted. The surveillance will be conducted by the FMC Project Manager or designee. The field surveillance will focus on adherence to procedures outlined in the FSP and will include field observation of sampling procedures and selected documentation (e.g. field log books). Laboratory audits will be conducted in accordance with the laboratory quality assurance plan. Field surveillance reports and laboratory audit reports will be forwarded to the FMC Environmental Manager. Audit findings which require corrective action and follow-up will be documented and tracked and will have resolution verified by the FMC Project Manager.

3.1 ASSESSMENTS AND RESPONSE ACTIONS

If it appears that field or laboratory data are in error, the error(s) or potential error(s) will be documented and appropriate corrective action(s) will be taken. Corrective actions may include one or more of the following:

- Measurements may be repeated to check the error
- Calibrations may be checked and/or repeated
- Instrument or measuring device(s) may be replaced or repaired
- New samples may be collected, and/or samples may be reanalyzed.

All field and laboratory personnel will be responsible for identification of problems and implementation of corrective actions. During field and laboratory activities, problem descriptions and corrective actions taken will be thoroughly detailed and entered into notebooks. If the FMC Project Manager, FMC Sampling Contractors, FMC Data Validation Contractor, Analytical Laboratory Contractors, or other project personnel become aware of any problems in sample collection or analysis that cannot be corrected in the field or laboratory, they will initiate formal corrective action and notify the FMC Project Manager and prepare a Corrective Action Report. The FMC Project Manager will also be notified of problems identified and corrective actions taken during field activities. Appropriate corrective actions will be determined on a case-by-case basis.

3.2 REPORTS TO MANAGEMENT

The surveillance and audit findings will be included in the corresponding groundwater monitoring results and data validation report. Each report, as appropriate, will include a section that provides an overall assessment of the performance of the field and laboratory programs based on the audits.

4.0 DATA VALIDATION AND USABILITY

The following subsection present requirements for activities that occur after the data collection phase of the project is complete.

4.1 DATA REVIEW, VALIDATION, AND VERIFICATION REQUIREMENTS

All data generated by this project will be reviewed by the FMC Environmental Manager or designee to ensure they are consistent with previous results and previously observed data trends. The data verification and validation activities will be in accordance with those used by FMC for its CERCLA and RCRA groundwater monitoring data over the past several years. These data verification and validation efforts are based on procedures recommended in *Guidance on Environmental Data Verification and Data Validation* (EPA QA/G-8, November 2002*)*. A Data Verification and Data Validation Protocol for FMC's Interim CERCLA, RCRA and Calciner Pond Remedial Action groundwater programs is included as Attachment C to the Groundwater Monitoring Plan that describes how FMC has routinely adapted the specifications set forth in the National Functional Guidelines to non-CLP methods, the personnel that have been involved, the inputs to the process, sources of the inputs, how the process has been implemented, and the outputs of the process.

4.2 VALIDATION AND VERIFICATION METHODS

The required data review will be conducted during report preparation; it will include a comparison of the current and previous results for water levels and chemical parameters measured at each well sampled. The data verification and validation methods will be in accordance with those used by FMC for its CERCLA, Calciner Pond and RCRA groundwater monitoring data over the past several years. These data verification and validation efforts are based on procedures recommended in *Guidance on Environmental Data Verification and Data Validation* (EPA QA/G-8. EPA/240/R-02/004, November 2002*)*.

4.3 RECONCILIATION WITH USER REQUIREMENTS

EPA recommends that the QAPP "[d]escribe how the results obtained from the project or task will be reconciled with the requirements defined by the data user or decision maker. Outline the proposed methods to analyze the data and determine possible anomalies or departures from assumptions established in the planning phase of data collection. Describe how reconciliation with user requirements will be documented, issues will be resolved, and how limitations on the use of the data will be reported to decision makers." (QA/R-5, EPA 2001, Section 3.5.3). As noted in QA/R-5, this corresponds to Step 7 of the DQO process.

The process to be followed in reviewing groundwater-monitoring data against user requirements is described below. Figure B-2 illustrates the steps described in these sections.

Review of Analytical Data

Once analytical data for samples collected during a groundwater-sampling event have been reviewed by the analyst and the Analytical Laboratory QA Officer and are determined to be useable, they are reported to the Groundwater Sampling Contractor (GSC), who then forwards a copy of the data to the Data Validation Contractor (DVC). The DVC will review the analytical data reported by the laboratory as well as field sampling and sample handling records submitted by the GSC.

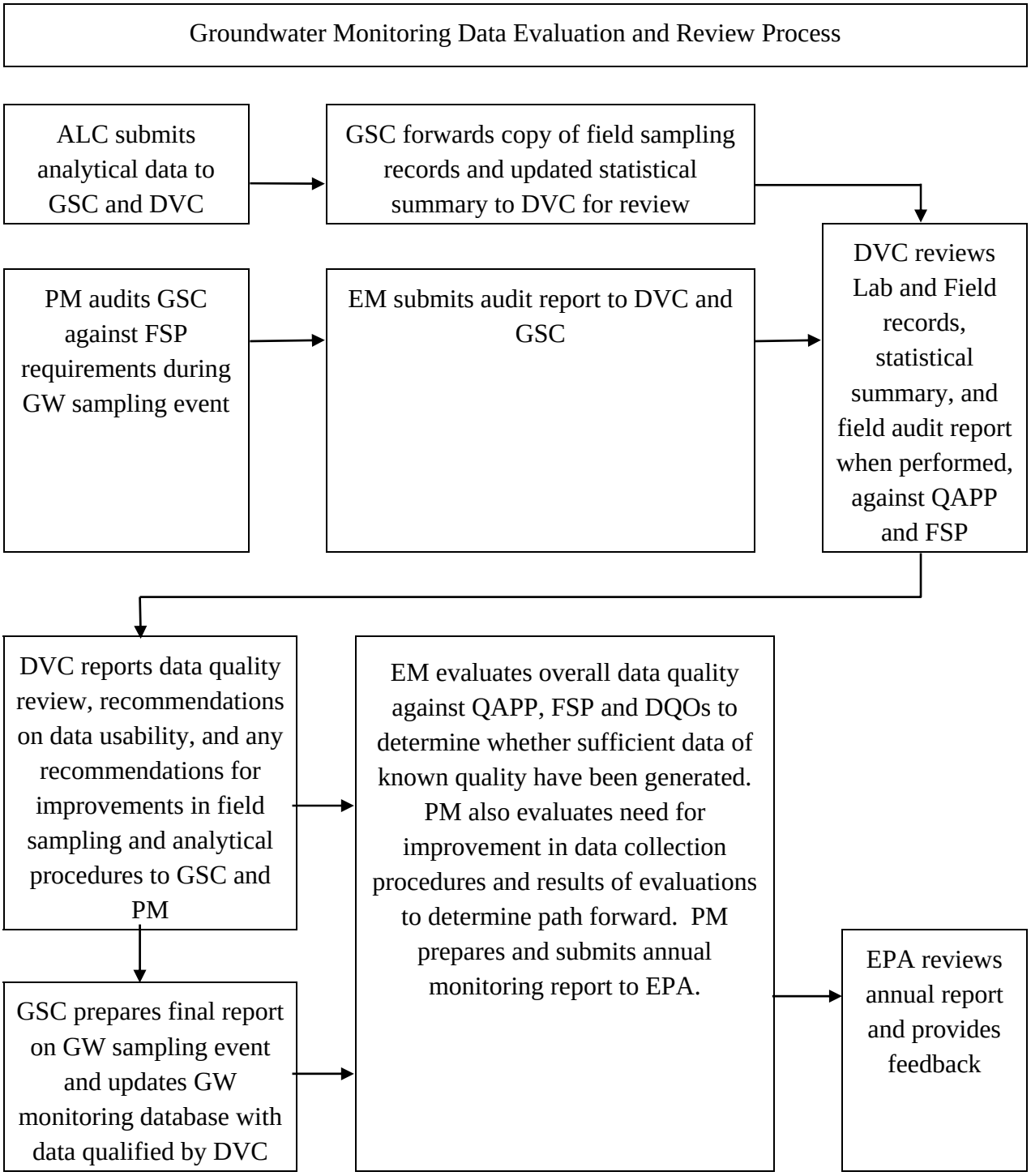
In addition, the FMC Project Manager (or designee) will perform periodic audits of the performance of the GSC against the requirements of the Field Sampling Plan (Attachment A to the Groundwater Monitoring Plan).

The FMC Project Manager will prepare an audit report and submit this to the DVC and the GSC. The DVC will review the audit report and evaluate these findings as part of the review of data provided by the analytical laboratory and GSC. Based on these inputs, the DVC will determine the quality of the data and assign appropriate data qualification flags in accordance with EPA's Functional Guidelines and this QAPP.

The DVC will submit a report to the FMC Project Manager and the GSC containing the results of the data review process, recommendations on data usability, and any recommendations for improvements in field sampling and analytical procedures.

The GSC will then prepare a report containing field-sampling data; a figure displaying groundwater elevation contours for wells sampled during the monitoring event, analytical reports submitted by the Analytical Laboratory and the DVC. The Groundwater Sampling Contractor will also add the field measurements, analytical data, and data validation flags to the project groundwater-monitoring database. This compilation report and updated database will be submitted to the FMC Project Manager for further review and reconciliation with user requirements.

FIGURE B-2. DATA VALIDATION AND USABILITY PROCESS



NOTES:
ALC = Analytical Laboratory Contractor, DVC = Data Validation Contractor, PM = FMC Project Manager, FSP = Field Sampling Plan, GSC = Groundwater Sampling Contractor, QAPP = Quality Assurance Project Plan.

Data Usability Determination

Reconciliation with DQOs determines the usability and limitation of the analytical data with respect to its intended purpose. Attainment of DQOs in fulfillment of program objectives described in this QAPP and the Field Sampling Plan (Attachment A to the Groundwater Monitoring Plan) is partly determined by a qualitative and quantitative assessment of the data collection and measurement process.

The principal DQO for the Interim CERCLA Groundwater Monitoring Plan from Step 2 of the DQO process is:

> *Are concentrations of site-related groundwater constituents stable or decreasing in wells 1) downgradient from identified FMC source areas, 2) downgradient from the joint fenceline area and both EMF facility sites, and 3) along the northern perimeter and not site-impacted to date. If increasing concentration trends are identified, evaluate / identify likely cause and mitigation plan if related to FMC source(s).*

The qualitative assessment of accumulated data against this DQO is the responsibility of the FMC Project Manager. Groundwater monitoring data are evaluated for conformance with required sample collection procedures, sampling handling, and analytical requirements and procedures. The data are also evaluated for previously unknown spatial or temporal variations that may affect sample representativeness. This evaluation is based on surveillance activities conducted by the EM and quantitative assessment of data quality by the DVC, as noted earlier in this section.

The FMC Project Manager evaluates overall data quality against QAPP, FSP, and DQOs to determine whether sufficient data of known quality have been generated. The EM also evaluates any need(s) for improvement in data collection procedures and then determines a path forward.

The FMC Project Manager determines if the data are adequate for the quantitative assessments described in Step 5 of the DQO process, as listed below. For groundwater monitoring data, a statistical analysis of the groundwater quality data using the Mann-Kendall Trend Test at the 95% confidence level is performed for arsenic, potassium, total phosphorus / orthophosphate, selenium and sulfate. The results of the statistical analyses of the interim CERCLA groundwater monitoring program data, in coordination with the RCRA and Calciner Pond Remedial Action groundwater monitoring programs and Simplot's remedial action groundwater monitoring data, will be used to evaluate groundwater conditions on a FMC Plant OU-wide basis.

DQO Step 5 Decision Rules

- Using the Mann-Kendall Trend Analysis, are there upward trends in arsenic, potassium, total phosphorus / orthophosphate, selenium and sulfate concentrations in samples collected from:
    - On-Plant Site wells: 139, 134, 151, 159 and 145 (in the joint fenceline area)
    - Plant Site downgradient wells: 111, 146, 110 and TW-9S
    - Wells downgradient from the FMC and Simplot Plant sites: 517 and TW-12S
    - Northern perimeter wells: 523, 515, 502, TW-11S, 524 and 525
- If so, are the upward trends attributable to EMF sources as follows:
    - On-Plant Site wells: Are trends at well 139, 134, 151 and/or 159 related to releases from the closed RCRA ponds, per results of evaluations (output) from RCRA annual assessment report, or are the changes more likely related to the former unlined phossy ponds in the western ponds area? Is trend at well 145 consistent with trends observed at the other wells in the joint fenceline area per annual Calciner Pond Remedial Action groundwater monitoring report?
    - Plant Site downgradient wells: Are trends at well 111 and/or 146 related to releases from the closed RCRA ponds or the closed RCRA slag pit sump, per output from RCRA annual assessment report, or are the changes more likely related to the former unlined phossy ponds in the western ponds area? Is trend at well 110 consistent with trends observed at the other wells in the joint fenceline area per output from annual Calciner Pond Remedial Action groundwater monitoring report?
    - Wells downgradient from the FMC and Simplot Plant sites: Are trends at well 517 and/or TW-12S related to releases from FMC sources, per output from annual RCRA and Calciner Pond groundwater reports, or are the changes more likely related to Simplot sources based on review of Simplot groundwater monitoring results?
    - Northern perimeter wells: Are trends related to undetected results at higher detection limit? If not, are results higher than relevant comparative value (CV) per Table 4-1 of the GMP. If so, are the trends consistent with trends observed at the nearest cross-gradient well(s) within the EMF-impacted area or are the changes more likely related to non-EMF sources?
- If the upward trend(s) are attributed to the closed RCRA ponds or Calciner Pond Remedial Action based on the evaluations / assessments under those programs,

further evaluation and potential mitigation plan(s) will be performed under those programs. If the upward trend(s) are attributable to Simplot sources, Simplot retains responsibility for the performance of Simplot's remedial actions. If the upward trends are attributable to FMC source areas identified for CERCLA remedial action, ensure remedial design addresses mitigation of identified and potential future sources of groundwater impacts that could exceed the CVs (MCLs, secondary standards or RBCs).

REFERENCES

EPA, 2001. "Requirements for Quality Assurance Project Plans for Environmental Data Operations," EPA QA/R-5, March 2001.

EPA, July 2002. "Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, Final", EPA 540-R-01-008, July 2002.

EPA, November 2002. "Guidance on Environmental Data Verification and Data Validation" EPA QA/G-8, November 2002.

FMC, June 2009. "Groundwater Current Conditions Report (GWCCR) for the FMC Plant Operable Unit," June 2009.

ATTACHMENT C

DATA VERIFICATION AND DATA VALIDATION PROTOCOL

DATA VERIFICATION AND VALIDATION PROTOCOL FMC POCATELLO, IDAHO RCRA, CERCLA, AND CALCINER POND GROUNDWATER MONITORING PROGRAMS

Rev July 2010

1. INTRODUCTION

This protocol describes the procedures used by FMC Idaho, LLC for verification and validation of analytical data obtained from groundwater samples collected for the RCRA, CERCLA and Calciner Pond Remedial Action groundwater monitoring programs for the FMC plant site located in Pocatello, Idaho. The groundwater monitoring programs are performed pursuant to the RCRA Interim Status Groundwater Monitoring Plan as updated in the RCRA Post Closure Plans (FMC, 1999), the Calciner Pond Remedial Action Groundwater Monitoring Plan (FMC, November 2008) and the Interim CERCLA Groundwater Monitoring Plan (FMC, March 2010). The verification and validation procedures are in accordance with EPA's *Guidance on Environmental Data Verification and Data Validation*, EPA QA/G-8, (EPA, November 2002).

To reduce the potential for real or perceived conflicts of interest, FMC engages a third party data validation contractor (DVC) to perform the functions described in this protocol. Figure C-1 is a flow chart providing a general overview of the FMC project team and contractors role and flow of the data review and evaluation process used by FMC for the RCRA, CERCLA, and Calciner Pond Remedial Action groundwater monitoring programs. A list of the analytical parameters and analytical methods associated with the RCRA, CERCLA and Calciner Pond Remedial Action groundwater monitoring programs is provided in Table C-1. For all parameters except ammonia RCRA methods provided in the SW-846 Manual are selected for the appropriate parameters. For ammonia a RCRA method is not provided in the SW-846 Manual, therefore, a method listed in Methods for Chemical Analysis of Water and Wastewater approved for NPDES monitoring has been utilized.

Data Verification

The data verification process is an adaptation of the guidance set forth in the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA July 2002), revisions contemporary with the activity (Guidelines), as well as to the specifications of the non-CLP methods and , as well as program-specific performance goals. As indicated in the QAPP, the DVC performs a Level III data verification for these programs. Level III verification involves a review of all administrative documents, including field and laboratory chain-of-custody documents, sample preservation records, and sample preparation logs. For all precision and accuracy evaluations, laboratory summary information and forms are evaluated as indicated for the individual methods. Any observation from this process that may have potential impact on data utility or defensibility is narrated in the verification summary. Any actions or qualifications are also narrated and tabulated in the verification summary. The data verification reports are appended to the data usability summary.

Data Validation

The data validation process involves a review of all verification information, as well as other available site-chemistry information including statistical trend analysis focused on the potential impact of non-compliances on the ability to make the decision. The product of this effort is a data usability summary narrating all outliers and their potential impacts on the ability to address the regulatory standards as well as a tabular presentation for easy reference. A definition of all data qualifiers used by the DVC, as indicated in the Guidelines, is presented in Table C-2. The data verification reports are appended to the data usability summary.

2. TECHNICAL REVIEW OF METHOD 6010B AND 6020

For Method 6010B and 6020 the following items are evaluated by the DVC:

- Calibration
- Blanks
- ICP Interference Check Sample (ICS)
- Laboratory Control Sample (LCS)
- Duplicate Sample Analysis
- Spike Sample Analysis
- ICP Serial Dilution
- ICP-MS Internal Standards
- Field Duplicates
- Detection Limits
- Overall Assessment

If all criteria, as defined below, are met for the indicated item, it is noted with an asterisk and so defined in the narrative.

PRESERVATION AND HOLDING TIMES:

The DVC reviews the chain-of-custody documentation, sample receipt logs, and sample preparation and analysis logs. If the required preservation conditions are violated, the data reported $\geq$ Reporting Limit (RL) are will be flagged by the DVC as estimated low (J-) and non-detected values are will be qualified as unusable (R).

CALIBRATION:

a. Initial Calibration:

The DVC reviews the initial calibration summary. If an initial calibration was not performed, quality the DVC will qualify the data for all analytes from the samples in the analytical set as unusable (R). If an initial calibration provides recoveries above the upper limit, the data for the non-compliant analyte(s) reported $\geq$ RL for all samples analyzed with the calibration are will be flagged by the DVC as estimated

high (J+). If an initial calibration provides recoveries below the lower limit, the DVC will qualify the data for the non-compliant analyte(s) as estimated low (J-, UJ-).

b. Continuing calibration.

If a continuing calibration was not performed at the required frequency, the DVC will qualify the data for all analytes from the samples in the analytical set between the continuing calibrations as unusable (R). If a continuing calibration provides recoveries above the upper limit, the data for the non-compliant analyte(s) reported ≥ RL for all samples analyzed before and after the non-compliant calibration will be are flagged by the DVC as estimated high (J+). If a continuing calibration provides recoveries below the lower limit, the DVC will qualify the data for the non-compliant analyte(s) as estimated low (J-, UJ-).

c. Low-level calibration verification.

If the laboratory performs a low-level calibration verification (e.g. at or near the RL), and recoveries are reported below the lower limit, the DVC will qualify the results from non-compliant analyte(s) reported <2RL for the samples associated with the standard as estimated low (J-). If the recoveries are reported above the upper limit, the DVC will qualify the results from non-compliant analyte(s) reported positive but <2RL for the samples associated with the standard as estimated high (J+).

BLANKS:

The DVC will review the results reported for all blanks. These include initial calibration blanks, continuing calibration blanks, preparation blanks, and field blanks. The initial calibration blanks, continuing calibration blanks, and preparation blanks should not be reported with analytes present at concentrations >MDL. If any are reported above the MDL, the DVC will indicate this in the narrative as a method non-conformance. For all blanks, the DVC will calculate the action levels at five times the reported blank concentration. Any associated sample values reported below the action level will be qualified by the DVC as not-detected (U) at the reported value. For blanks reported with negative values, the DVC will determine that whether the RL or reported values above the RL are greater than five times the absolute value of the negative blank. Positive values and RL values less than five times the absolute value of the negative blank will be are flagged by the DVC as estimated low (J-).

ICP INTERFERENCE CHECK SAMPLE:

The DVC will review the results reported for the interference check standard. For values above the upper limit, the DVC will qualify all associated sample data that are reported ≥ RL for the analyte(s) as estimated high (J+). For values below the lower limit, the DVC will qualify all associated sample data for the analyte(s) as estimated low (J-, UJ-).

LABORATORY CONTROL SAMPLE:

The DVC will review the results reported for the laboratory control sample. For values above the upper limit, the DVC will qualify all associated sample data that are reported ≥ RL for the analyte(s) as estimated high (J+). For values below the lower limit, the DVC will qualify all associated sample data for the analyte(s) as estimated low (J-, UJ-). The DVC will indicate in the narrative that non-compliant LCS results without re-digestion and reanalysis are not compliant with method requirements.

DUPLICATE SAMPLE ANALYSIS:

The DVC will review the results reported for the laboratory replicate analysis. For situations where both the sample and replicate sample are reported with concentrations >5 RL of analyte RPD limits will be used and when either one or both are reported with <5 RL of analyte |S-D| limits will be used. The DVC will qualify the results reported for the non-compliant analyte(s) for all samples in the analytical batch as estimated (J, UJ). If a duplicate sample was not analyzed at the required frequency, the DVC will indicate in the narrative as a method non-conformance.

SPIKE SAMPLE ANALYSIS:

The DVC will review the results reported for the matrix spike (MS)/matrix spike duplicate (MSD) analysis. For situations where the native level is greater than four times the spiking level, the matrix spike recoveries are not evaluated. For situations where the native level is less than four times the spiking level, and non-compliant recoveries are reported, the DVC will qualify the results for all samples in the batch as estimated low (J-, UJ-) if below the limit and positive results as estimated high (J+) if above the upper limit. If the RPD of MS/MSD is out of specification, the DVC will qualify the results for the element(s) reported in all samples associated with the batch as estimated (J, UJ). If a matrix spike/matrix spike duplicate sample was not analyzed at the required frequency, the DVC will indicate this in the narrative as a method non-conformance.

ICP SERIAL DILUTION:

The DVC will review the results reported for the serial dilution analysis. For samples reported with >50 MDL of analyte in the undiluted sample providing non-compliant %D, the DVC will qualify the results for the element(s) in all samples associated with the batch as estimated (J, UJ). The DVC will comment in the narrative the indicated bias direction (, e.g. if the diluted value is higher than the undiluted value, low bias is indicated).

ICP-MS INTERNAL STANDARDS:

The DVC will review the results reported for internal standards (IS) and verify that the proper IS were used throughout the analytical sequence and were present in all samples, QC samples, and standards. The DVC will also verify that the % relative intensities (RI) of the IS are in specification, and if out of specification that the proper dilution and reanalysis was employed. If

no internal standards were analyzed with the run or an inappropriate IS was utilized the DVC will qualify all affected sample results as unusable (R). If the RI is out of specification or an appropriate dilution was not applied the DVC will qualify all impacted element results as estimated (J).

FIELD DUPLICATES:

The DVC will review the results reported for the field duplicate analysis. For situations where both the sample and field duplicate sample are reported with concentrations >5 RL of analyte RPD limits will be used and when either one or both are reported with <5 RL of analyte |S-D| limits will be used. The DVC will qualify the results reported for the non-compliant analyte(s) for all samples in the analytical batch as estimated (J, UJ).

DETECTION LIMITS:

The DVC will review the reporting limits regarding their reasonableness with method-stated values and with respect to MDL, if reported in the data package. The DVC will narrate any deviations from method requirements for reporting limits. If the laboratory is required to report values below the method-stated values, the DVC will narrate the statistical implications and qualify values below the statistically valid limit as estimated (J).

OVERALL ASSESSMENT:

In the overall assessment, the DVC will provide a brief summary of all items and QC outliers indicated in the narrative report.

3. TECHNICAL REVIEW OF METHODS 9056, 365.2, 350.3, 9010C, 9012B and 7580

For Method 9056, 365.2, 350.3, 9010C, 9012B and 7580 the following items are evaluated by the DVC:

- Preservation and Holding Times
- Calibration
- Blanks
- Laboratory Control Sample (LCS)
- Duplicate Sample Analysis
- Spike Sample Analysis
- Field Duplicates
- Detection Limits
- Overall Assessment

If all criteria, as defined below, are met for the indicated item, it is noted with an asterisk and so defined in the narrative.

PRESERVATION AND HOLDING TIMES:

The DVC will review the chain-of-custody documentation, sample receipt logs, and sample preparation and analysis logs. If the required preservation conditions are violated and/or the holding time has been exceeded, and where studies have not shown that the exceedence has no significant impact on sample integrity for the parameter, the data reported for the parameter are flagged by The DVC as estimated low (J-). For significant holding time exceedences (e.g. >2 times the published limit) that have not shown that the exceedence has no significant impact on sample integrity for the parameter, associated non-detected values are qualified by the DVC as unusable (R).

CALIBRATION:

a. Initial Calibration:

The DVC will review the initial calibration summary. If an initial calibration was not performed, the DVC will qualify the data for all analytes from the samples in the analytical set as unusable (R). If an initial calibration was performed with fewer than the method-specified number of concentrations, the DVC will narrate the finding as a method deviation and qualify all associated sample results as estimated (J, UJ). The DVC will verify that the method-specified linear regression quantitation model was used to calculate sample concentrations. If it was not, the DVC will narrate the finding as a method deviation and qualify all associated sample results as estimated (J).

b. Continuing calibration.

If a continuing calibration was not performed at the required frequency, quality the DVC will qualify the data for all analytes from the samples in the analytical set between the continuing calibrations as unusable (R). If a continuing calibration provides recoveries above the upper limit, the data for the non-compliant analyte(s) reported $\geq$ RL for all samples analyzed before and after the non-compliant calibration are will be flagged as estimated high (J+). If a continuing calibration provides recoveries below the lower limit, the DVC will qualify the data for the non-compliant analyte(s) for all samples analyzed before and after the non-compliant calibration as estimated low (J-, UJ-).

BLANKS:

The DVC will review the results reported for all blanks. These include initial calibration blanks, continuing calibration blanks, and field blanks. The initial calibration blanks, and continuing calibration blanks should not be reported with analytes present at concentrations >MDL. If any are reported above the MDL, the DVC will indicate this in the narrative as a method non-conformance. For all blanks, the DVC will calculate the action levels at five times the reported blank concentration. Any associated sample values reported below the action level are will be qualified by the DVC as not-detected (U) at the reported value. For blanks reported with negative values, the DVC will determine that the RL or reported values above the RL are greater

than five times the absolute value of the negative blank. Positive values and RL values less than five times the absolute value of the negative blank will be are flagged by the DVC as estimated low (J-).

LABORATORY CONTROL SAMPLE:

The DVC will review the results reported for the laboratory control sample. For values above the upper limit, the DVC will qualify all associated sample data that are reported ≥ RL for the analyte(s) as estimated high (J+). For values below the lower limit, the DVC qualify all associated sample data for the analyte(s) as estimated low (J-, UJ-). The DVC will indicate in the narrative that non-compliant LCS results without reanalysis are not compliant with method requirements.

DUPLICATE SAMPLE ANALYSIS:

The DVC will review the results reported for the laboratory replicate analysis. For situations where both the sample and replicate sample are reported with concentrations >5 RL of analyte RPD limits will be used and when either one or both are reported with <5 RL of analyte |S-D| limits will be used. The DVC will qualify the results reported for the non-compliant analyte(s) for all samples in the analytical batch as estimated (J, UJ). If a duplicate sample was not analyzed at the required frequency, the DVC will indicate in the narrative as a method non-conformance.

SPIKE SAMPLE ANALYSIS:

The DVC will review the results reported for the matrix spike (MS)/matrix spike duplicate (MSD) analysis. For situations where the native level is greater than four times the spiking level, the DVC will not evaluate the matrix spike recoveries are not evaluated. For situations where the native level is less than four times the spiking level, and non-compliant recoveries are reported, the DVC will qualify the results for all samples in the batch as estimated low (J-, UJ-) if below the limit and positive results as estimated high (J+) if above the upper limit. If the RPD of MS/MSD is out of specification, the DVC will qualify the results for the element(s) reported in all samples associated with the batch as estimated (J, UJ). If a matrix spike/matrix spike duplicate sample was not analyzed at the required frequency, the DVC will indicate this in the narrative as a method non-conformance.

FIELD DUPLICATES:

The DVC will review the results reported for the field duplicate analysis. For situations where both the sample and field duplicate sample are reported with concentrations >5 RL of analyte RPD limits will be used and when either one or both are reported with <5 RL of analyte |S-D| limits will be used. The DVC will qualify the results reported for the non-compliant analyte(s) for all samples in the analytical batch as estimated (J, UJ).

DETECTION LIMITS:

The DVC will review the reporting limits regarding their reasonableness with method-stated values and with respect to MDL, if reported in the data package. The DVC will narrate any deviations from method requirements for reporting limits. If the laboratory is required to report values below the method-stated values, the DVC will narrate the statistical implications and qualify values below the statistically valid limit as estimated (J).

OVERALL ASSESSMENT:

In the overall assessment, the DVC will provide a brief summary of all items and QC outliers indicated in the narrative report.

4. PREPARATION OF DATA VALIDATION/USABILITY REPORT

For each event, a Data Validation/Usability Report (Report) is prepared by the DVC for each groundwater sampling event. The Report will summarize the event, indicate when the samples were collected, attach the reports provided by the laboratory, indicate what analyses were performed, indicate what analytical methods were used, indicate what procedures were used for the technical review, and indicate what guidance and standards were used for the usability assessment.

The data usability issues are also summarized and discussed in the usability narrative of the Report. The data quality indicators assessed by the DVC are precision, accuracy, representativeness, comparability, completeness, and consistency.

PRECISION

The precision of laboratory replicate analysis as well as field duplicate samples is will be discussed in the Report. The impacts of any outliers from method and program document specification will be identified and an assessment will be presented on the potential impact of these outliers on the utility of the datum in question.

ACCURACY

The accuracy (bias) indications resulting from calibrations, spikes, serial dilutions, and standard reference materials are will be discussed in the Report. The impacts of any outliers from method and program document specification will be identified and an assessment will be presented on the potential impact of these outliers on the utility of the datum in question.

REPRESENTATIVENESS

The factors contributing to representativeness (e.g., well preparation prior to collection, collection of collocated samples, container cleanliness, preservation, blank contamination, and time from collection to analysis) will be are discussed in the Report. The impacts of any outliers from method and program document specification will be

identified and an assessment will be presented on the potential impact of these outliers on the utility of the datum in question.

COMPARABILITY

The factors contributing to comparability (e.g., consistency of reporting units, QA/QC procedures, sampling techniques, and analytical procedures utilized) will be discussed in the Report. The impacts of any outliers from method and program document specification will be identified and an assessment will be presented on the potential impact of these outliers on the utility of the datum in question.

COMPLETENESS

An assessment of the extent of completeness (e.g., usable data obtained *vs.* usable data program goals) will be discussed in the Report. The potential impact of lack of achievement of completeness goals is will be narrated.

CONSISTENCY

A comparison of the event data with the historical trend is will be performed. The impacts of any outliers from statistical expectations will be addressed as well as the need and extent of further consistency evaluations. The potential impact of lack of consistency with historical trends on the utility of the data is will be narrated in the Report.

REFERENCES:

EPA, 1983. "Methods for Chemical Analysis of Water and Wastes", USEPA 600/4-79-020, March 1983 and subsequent revisions.

EPA, 1986. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846 Third Edition, November 1986 and subsequent revisions.

EPA, 2001. "Requirements for Quality Assurance Project Plans for Environmental Data Operations," EPA QA/R-5, March 2001.

EPA, 2002. "Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" July 2002.

EPA, November 2002. "Guidance on Environmental Data Verification and Data Validation" EPA QA/G-8, November 2002.

FMC, 1999. "RCRA Interim Status Groundwater Monitoring Plan", Bechtel Environmental, August 1999; as updated in the RCRA Post-Closure Plans as follows:

- Pond 9E post-closure plan, January 2000;
- Slag Pit Sump post-closure plan, September 2001;
- Pond 8E, Phase IV Ponds and Pond 15S post-closure plans, May 2002;
- Pond 16S post-closure plan, July 2003; and,
- Pond 17 and Pond 18 Cell A post-closure plans, August 2004.

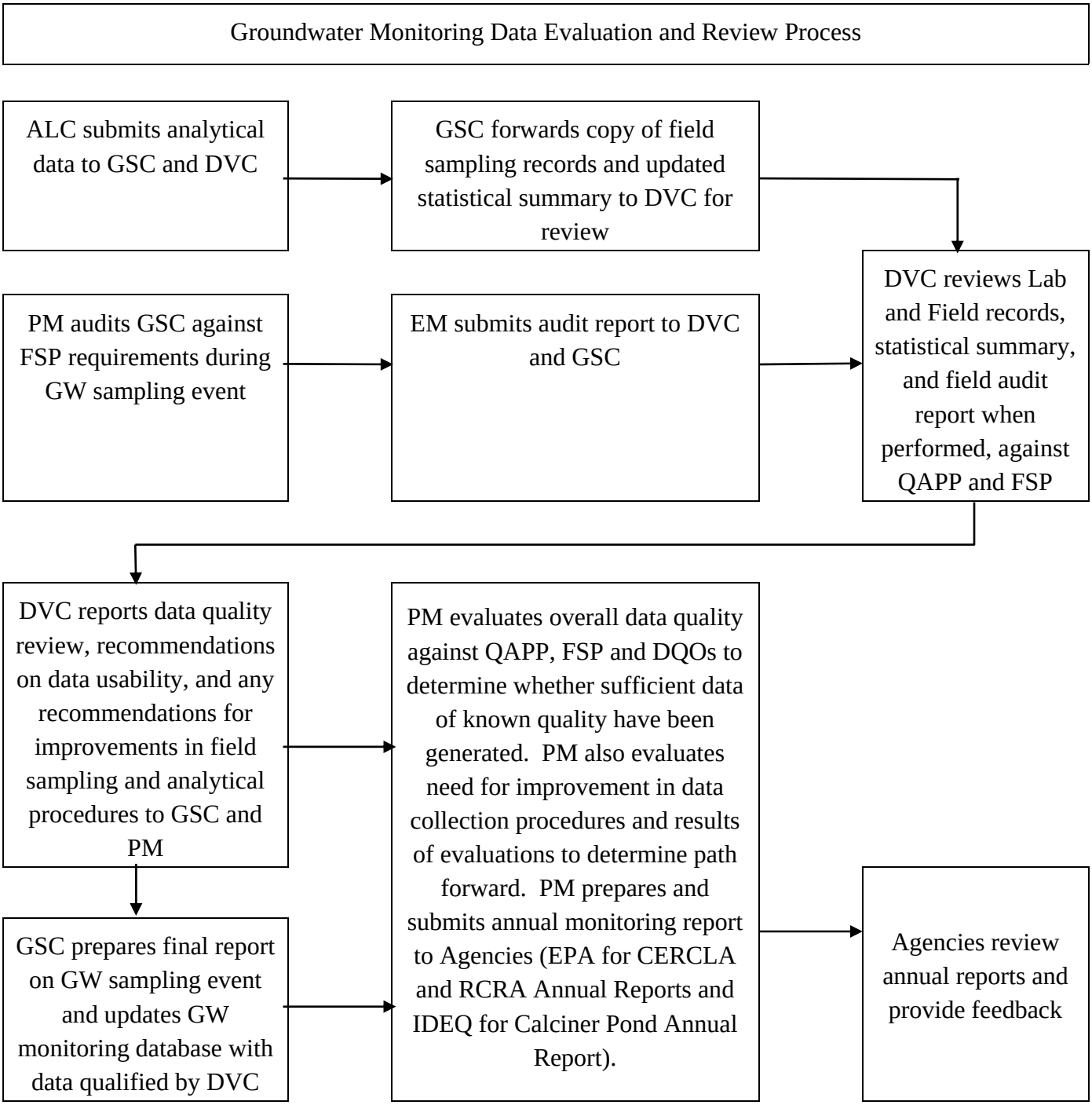
FMC Idaho LLC (FMC), November 2008. "Calciner Pond Remedial Action Groundwater Monitoring Plan," May 2008, Revised November 2008.

FMC, March 2010. "Interim CERCLA Groundwater Monitoring Plan," March 2010.

TABLE C-1 Analytical Parameters and Methods Associated with the FMC Groundwater Monitoring Programs		
Analytical Parameters	**Method**	**Program**
Arsenic	6010 or 6020	All
Potassium	6010 or 6020	All
Total phosphorus	6010 or 6020 or 365.2	All
Selenium	6010 or 6020	All
Cadmium	6010 or 6020	RCRA
Boron	6010 or 6020	CERCLA
Manganese	6010 or 6020	CERCLA
Vanadium	6010 or 6020	CERCLA
Chloride	9056	All
Fluoride	9056	All
Nitrate	9056	All
Orthophosphate	365.2	RCRA
Sulfate	9056	All
Ammonia	350.3	All
Cyanide	9010C or 9012B	CERCLA
Elemental phosphorus	7580	RCRA

TABLE C-2 DATA QUALIFIER DEFINITIONS	
U	The analyte was analyzed for, but was not detected above the level of the sample quantitation limit.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting Quality Control criteria. The analyte may or may not be present in the sample.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

FIGURE C-1 Data Evaluation and Review Process



NOTES:
ALC = Analytical Laboratory Contractor, DVC = Data Validation Contractor, PM = FMC Project Manager, FSP = Field Sampling Plan, GSC = Groundwater Sampling Contractor, QAPP = Quality Assurance Project Plan.

Soil Remedial Alternative 2

Key Assumptions:
Capital Costs in 2009 dollars.
Annual O&M costs in 2009 dollars.
No costs incurred for future receptor initiated remediation.
Groundwater Monitoring is captured in groundwater cost spreadsheet.
All caps will require 3% slope.
5% of construction costs was assumed for stormwater management.
All ET covers assumes 24 inches of soil as presented in Section 4 of the Cap Memorandum (June, 2009).

All required cover soil for caps available onsite from Western Borrow Area.
Assume 1,675,800 yd3 of fill in slag pile based upon leaving valley down center of slag pile (using 2001 Bechtel estimate scaled up from 100 acres to 171 acres).
All fill for grading and capillary break will be obtain onsite from crushed slag sources.

RA Specific Remedial Costs	Capital Cost 2009 Dollars	Annual O&M Cost 2009 Dollars	NPV
RA-A			
1. Institutional Controls (costs captured as part of environmental controls)			
Subtotal RA A			
RA-B			
1. Grade to 3%	$47,000		$47,000
2. Construct ET cap	$1,011,670		$1,011,670
3. PH3 vapor/PH3 Monitoring Probe Installation	$3,000		$3,000
4. Institutional Controls (costs captured as part of environmental controls)			
5.Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$13,200	$34,637
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$21,900	$271,753
Subtotal RA B	**$1,062,000**	**$36,000**	**$1,369,000**
RA-C			
1. Grade to 3%	$112,800		$112,800
2. Construct ET cap	$3,235,100		$3,235,100
3. PH3 Monitoring Probe Installation	$8,000		$8,000
4. Institutional Controls (costs captured as part of environmental controls)			
5.Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$35,200	$92,365
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$70,030	$869,007
Subtotal RA C	**$3,356,000**	**$106,000**	**$4,318,000**
RA-D			
1. Grade to 3%	$940,000		$940,000
2. Construct ET Cap	$3,142,535	`	$3,142,535
3. Institutional Controls (costs captured as part of environmental controls)			
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$68,027	$844,143
Subtotal RA D	**$4,083,000**	**$69,000**	**$4,927,000**
RA-E			
1. Grade to 3%	$47,000		$47,000
2. Construct ET cap	$1,982,200		$1,982,200
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$42,909	$532,455
Subtotal RA E	**$2,030,000**	**$43,000**	**$2,562,000**
RA-F			
1. Grade to 3:1 slope	$3,150,504		$3,150,504
2. Gamma Cap	$4,890,600		$4,890,600
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$94,050	$1,167,066
Subtotal RA F	**$8,042,000**	**$95,000**	**$9,209,000**
RA-G			
1. Recetor Initiated Remediation	$0		$0
RA-H			
1. Grade to 3% slope	$9,400		$9,400
2. Construct ET Cap	$1,636,250		$1,636,250
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$35,420	$439,527
Subtotal RA H	**$1,646,000**	**$36,000**	**$2,086,000**
RA-K			
1. ET Cap	$121,550		$121,550
2. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$2,631	$32,651
Subtotal RA K	**$122,000**	**$3,000**	**$155,000**
Storm Sewer Piping			
1. Clean and Treat Off-Site	$27,672		$27,672
Subtotal Sewer Piping	**$28,000**	**$0**	**$28,000**
Ancillary Sitewide Actions			
Seal all non-P4 piping/conduits that exit ET caps	$500,000		$500,000
Mob/Demob (1% of construction costs)	$183,390		$183,390
Stormwater Management (5% of construction costs)	$916,950		$916,950
Environmental Controls (10% construction costs)	$1,833,900		$1,833,900
Subtotal Ancillary Sitewide Actions	**$3,435,000**	**$0**	**$3,435,000**
Reporting and Engineering			
Engineering Design (10% of construction costs)	$1,833,900		$1,833,900
Construction Management (15% of construction costs)	$2,750,850		$2,750,850
5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)		$15,000	$10,695
10 year Review (NPV assumes discount factor of 0.508 for 7% discount rate)		$15,000	$7,625
15 Year Review (NPV assumes discount factor of 0.362 for 7% discount rate)		$15,000	$5,437
20 Year Review (NPV assumes discount factor of 0.258 for 7% discount rate)		$15,000	$3,876
25 Year Review (NPV assumes discount factor of 0.184 for 7% discount rate)		$15,000	$2,764
30 Year Review and Closure Report (NPV assumes discount factor of 0.131 for 7% discount rate)		$50,000	$6,568
Subtotal Reporting and Engineering	**$4,585,000**	**$125,000**	**$4,622,000**
Total Cost	**$28,389,000**	**$513,000**	**$32,711,000**

ASSUMPTIONS AND CALCULATIONS

Unit Rates

Item	Cost	Unit	Cost Backup
Fencing	NA	ft	Assumed to be captured as part of environmental controls
ET Capping	$85,000.00	acre	Table 2
Gamma Capping	$26,000.00	acre	Table 3
Rough Site Grading	$1.88	CY	2009 RS Means 31.23.23.17 0011
Clean and Treat Storm Sewer Piping	$300.00	LF	Table 4
PH3 Monitoring Installation	$1,000.00	location/1000 ft	Engineering Assumption
PH3 Annual Monitoring	$4,400.00	location	Table 15
O&M for Gamma Caps	$500.00	acre/yr	Table 13
O&M for Caps	$1,840.00	acre/yr	Table 14

RA-A

General Assumptions:
Acerage 103
Receptor-initiated remediation costs are not included here.
Current access control is adequate.

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (costs captured as part of environmental controls)				

RA-B

General Assumptions: Cap Boundary
Acreage 10.82
PH3 monitoring required for first three years only.
ET cap 11.902

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (cost captured as part of environmental controls)			ft	
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	11.902	acre	$1,011,670
PH3 Monitoring Installation	$1,000.00	3	location	$3,000
Annual PH3 Monitoring	$4,400.00	3	location	$13,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	11.902	acre	$21,900

RA-C

General Assumptions: Cap Boundary
Acreage 34.6
PH3 monitoring required for first three years only.
ET cap 38.06
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (cost captured as part of environemntal controls)				
Rough Grading of Subgrade to 3%	$1.88	60000	CY	$112,800
ET Cap	$85,000.00	38.06	acre	$3,235,100
PH3 Monitoring	$1,000.00	8	location	$8,000
Annual PH3 Monitoring	$4,400.00	8	location	$35,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	38.06	acre	$70,030

RA-D

General Assumptions: Cap Boundary
Acreage 33.61
ET cap 36.971
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane Fence (costs captured as part of environemntal controls)			ft	
Rough Grading of Subgrade to 3%	$1.88	500000	CY	$940,000
ET Cap	$85,000.00	36.971	acre	$3,142,535
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	36.971	acre	$68,027

RA-E

General Assumptions: Cap Boundary
Acreage 21.2
ET cap 23.32
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	23.32	acre	$1,982,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	23.32	acre	$42,909

RA-F

General Assumptions: Acres Cap Boundary
Acreage 171 188.1
Gamma Cap
Site requires re-grading to establish minium 3:1 slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading to 3:1 slope	$1.88	1675800	CY	$3,150,504
Gamma Cap	$26,000.00	188.1	acre	$4,890,600
Annual O&M (includes cap integrity monitoring and repair)	$500.00	188.1	yr	$94,050

RA-G

General Assumptions: Acres Cap Boundary
Acreage 65.9
Receptor Initiated

RA-H

General Assumptions: Cap Boundary
Acreage 17.5
ET cap 17.5 19.25
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	5000	CY	$9,400
ET Cap	$85,000.00	19.25	acre	$1,636,250
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	19.25	acre	$35,420

Remedial Alternative 2
RA Cost Estimates and Assumptions

RA-I
General Assumptions:
Acerage 191
Receptor-initiated remediation costs are not included here.

Costing Calculations	Unit Cost	# Units	Units	Total
Annual O&M	$500.00	0	acre	$0

RA-J
General Assumptions:
Acerage 15
Receptor-initiated remediation costs are not included here.

Costing Calculations	Unit Cost	# Units	Units	Total
Annual O&M	$500.00	0	acre	$0

RA-K
General Assumptions: Cap Boundary
Acerage 1.3
ET CAP 1.43
Current access control is adequate.

Costing Calculations	Unit Cost	# Units	Units	Total
ET cap (railroad swale)	$85,000	1.43	acres	$121,550
O&M (includes cap integrity monitoring and repair)	$1,840.00	1.43	acre	$2,631

STORM SEWER PIPING
Linear Feet
Clean in Place and Treat Offsite

Costing Calculations	Unit Cost	# Units	Units	Total
Clean and Treat Offsite	$300	92.24	feet	$27,672

PROCESS PIPING
Linear Feet
Addressed as part of ET Caps on RAs B, C, and D

Ancillary Sitewide Actions

5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)	$15,000
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)	$15,000
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)	$15,000
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)	$15,000
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)	$15,000
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)	$50,000

Soil Remedial Alternative 3
FMC Pocatello Idaho, LLC.

Soil Remedial Alternative 3			
Key Assumptions: Capital Costs in 2009 dollars. Annual O&M costs in 2009 dollars. All caps will require 3% slope. Groundwater monitoring is captured in groundwater cost spreadsheet 5% of construction costs was assumed for stormwater management. All ET Caps assume a 24-inches thick cover as presented in the Cap Memorandum (June, 2009). All required cover soil for caps available onsite from Western Borrow Area. Assume 3,000,000 yd3 of fill in slag pile including backfilling of valley down center of slag pile. All fill for grading and capillary break will be obtain onsite from crushed slag sources.			
RA A Specific Remedial Costs	**Capital Cost 2009 Dollars**	**Annual O&M Cost 2009 Dollars**	**NPV**
RA-A			
1. Gamma Cap	$2,678,000		$2,678,000
2. Institutional Controls (costs captured as part of environmental controls)			
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$51,500	$639,064
Subtotal RA A	**$2,678,000**	**$52,000**	**$3,318,000**
RA-B			
1. Grade to 3%	$47,000		$47,000
2. Construct ET cap	$1,011,670		$1,011,670
3. PH3 Monitoring Probe Installation	$3,000		$3,000
4. Institutional Controls (costs captured as part of environmental controls)			
5. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$21,900	$271,753
6.Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$13,200	$34,637
Subtotal RA B	**$1,062,000**	**$36,000**	**$1,369,000**
RA-C			
1. Grade to 3%	$112,800		$112,800
2. Construct ET cap	$3,235,100		$3,235,100
3. PH3 vapor/PH3 Monitoring Probe Installation	$8,000		$8,000
4. Institutional Controls (costs captured as part of environmental controls)			
5. Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$35,200	$92,365
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$70,030	$869,007
Subtotal RA C	**$3,356,000**	**$106,000**	**$4,318,000**
RA-D			
1. Grade to 3%	$940,000		$940,000
2. Institutional Controls (costs captured as part of environmental controls)			$0
3. Construct ET Cap	$3,142,535		$3,142,535
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$68,027	$844,143
Subtotal RA D	**$4,083,000**	**$69,000**	**$4,927,000**
RA-E			
1. Grade to 3%	$47,000		$47,000
2. Construct ET cap	$1,982,200		$1,982,200
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$42,909	$532,455
Subtotal RA E	**$2,030,000**	**$43,000**	**$2,562,000**
RA-F			
1. Grade to 3:1 slope	$5,640,000		$5,640,000
2. Gamma Cap	$4,267,120		$4,267,120
3. ET cap	$2,038,300		$2,038,300
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$94,050	$1,167,066
Subtotal RA F	**$11,946,000**	**$95,000**	**$13,113,000**
RA-G			
1. Grade to 3% slope	$47,000		$47,000
2. Construct Gamma Cap	$1,881,880		$1,881,880
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$36,190	$449,082
Subtotal RA G	**$1,929,000**	**$37,000**	**$2,378,000**
RA-H			
1. Grade to 3% slope	$9,400		$9,400
2. Construct ET Cap	$1,636,250		$1,636,250
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$35,420	$439,527
Subtotal RA H	**$1,646,000**	**$36,000**	**$2,086,000**
RA-J			
1. Scrape to 6 inches	$375,000		$375,000
Subtotal RA J	**$375,000**	**$0**	**$375,000**
RA-K			
1.ET Cap	$121,550		$121,550
2. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$2,631	$32,651
Subtotal RA K	**$122,000**	**$3,000**	**$155,000**
Storm Sewer Piping			
1.Clean in Place/Treat OffSite	$27,672		$27,672
Subtotal Sewer Piping	**$28,000**	**$0**	**$28,000**
Ancillary Sitewide Actions			
Seal all non-P4 piping/conduits exiting ET caps	$500,000		$500,000
Mob/Demob (1% of construction costs)	$292,550		$292,550
Stormwater Management (5% of construction costs)	$1,462,750		$1,462,750
Environmental Controls (10% construction costs)	$2,925,500		$2,925,500
Subtotal Ancillay Actions	**$5,181,000**	**$0**	**$5,181,000**
Reporting and Engineering			
Engineering Design (10% of construction costs)	$2,925,500		$2,925,500
Construction Management (15% of construction costs)	$4,388,250		$4,388,250
5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)		$15,000	$12,939
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)		$15,000	$11,161
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)		$15,000	$9,628
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)		$15,000	$8,305
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)		$15,000	$7,164
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)		$50,000	$20,599
Subtotal Reporting and Engineering	**$7,314,000**	**$125,000**	**$7,384,000**
Total Cost	**$41,750,000**	**$602,000**	**$47,194,000**

Remedial Alternative 3
RA Cost Estimates And Assumptions

ASSUMPTIONS AND CALCULATIONS
Unit Rates

Item	Cost	Unit	Cost Backup
Fencing	NA	ft	Costs captured as part of envirnmental controls.
ET Capping	$85,000.00	acre	Table 2
Gamma Capping	$26,000.00	acre	Table 3
Rough Site Grading	$1.88	CY	2009 RS Means 31.23.23.17 0011
Scrape RA-J	$25,000.00	acre	Table 5
PH3 Monitoring Installation	$1,000.00	location/1000 ft	Engineerig Assumption
Clean and treat Stormwater Sewer Piping	$300.00	ft	Table 4
O&M for Gamma Caps	$500.00	acre/yr	Table 13
PH3 Annual Monitoring	$4,400.00	location	Table 15
O&M for Caps	$1,840.00	acre/yr	Table 14

RA-A
General Assumptions:
Acerage 103
Gamma cap
Gamma Cap on Hydrocarbon Impacted Soil
Current access control is adequate.

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (captured as part of environmental controls)				
Gamma Cap	$26,000	103	acres	$2,678,000
Annual O&M (includes cap integrity monitoring and repair)	$500.00	103	acre	$51,500

RA-B
General Assumptions: Cap Boundary
Acreage 10.82 11.902
PH3 monitoring required for first three years only.
Site requires re-grading to establish minium 3% slope
ET cap

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	11.902	acre	$1,011,670
PH3 Monitoring Installation	$1,000.00	3	location	$3,000
Annual PH3 Monitoring	$4,400.00	3	location	$13,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	11.902	acre	$21,900

RA-C
General Assumptions: Cap Boundary
Acreage 34.6 38.06
P4 monitoring required for first three years only.
ET cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	60000	CY	$112,800
ET Cap	$85,000.00	38.06	acre	$3,235,100
PH3 Monitoring Installation	$1,000.00	8	location	$8,000
Annual PH3 Monitoring	$4,400.00	8	location	$35,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	38.06	acre	$70,030

RA-D
General Assumptions: Cap Boundary
Acreage 33.61 36.971
ET cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane Fence (costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	500000	CY	$940,000
ET Cap	$85,000.00	36.971	acre	$3,142,535
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	36.971	acre	$68,027

RA-E
General Assumptions: Cap Boundary
Acreage 21.2 23.32
ET cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	23.32	acre	$1,982,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	23.32	acre	$42,909

RA-F
General Assumptions: Acres Cap Boundary
Acreage 171 188.1
Gamma Cap 149.2 164.12
ET cap over burried railroad cars and 19b 21.8 23.98
Site requires re-grading to establish minium 1% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading to 3:1 slope	$1.88	3000000	CY	$5,640,000
ET Cap	$85,000.00	23.98	acres	$2,038,300
Gamma Cap	$26,000.00	164.12	acre	$4,267,120
Annual O&M (includes cap integrity monitoring and repair)	$500.00	188.1	yr	$94,050

Remedial Alternative 3
RA Cost Estimates And Assumptions

RA-G

General Assumptions:	Acres	Cap Boundary
Acreage	65.8	72.38

Gamma Cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
Gamma Cap	$26,000.00	72.38	acre	$1,881,880
Annual O&M (includes cap integrity monitoring and repair)	$500.00	72.38	acre	$36,190

RA-H

General Assumptions:		Cap Boundary
Acreage	17.5	19.25

ET cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	5000	CY	$9,400
ET Cap	$85,000.00	19.25	acre	$1,636,250
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	19.25	acre	$35,420

RA-I

General Assumptions:
Acerage 191
Receptor-initiated remediation costs are not included here.

Costing Calculations	Unit Cost	# Units	Units	Total
Annual O&M	$500.00	0	acre	$0

RA-J

General Assumptions:
Acerage 15
Gamma Cap

Costing Calculations	Unit Cost	# Units	Units	Total
Scrape to 6 inhces	$25,000.00	15	acre	$375,000

RA-K

General Assumptions		Cap Boundary
Acreage	1.30	
ET Cap		1.43

Existing Fence is Adequate
Costing Calculations

Costing Calculations	Unit Cost	# Units	Units	Total
ET Cap	$85,000.00	1.43	acres	$121,550
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	1.43	acres	$2,631

Stormwater Sewer Piping

General Assumptions:
Linear Feet
Clean in Place and Treat Off-site

Costing Calculations	Unit Cost	# Units	Units	Total
Clean in Place and Treat Off-Site	$300.00	92.24	ft	$27,672

Process Piping

General Assumptions:
ET Cap (addressed as part of capping of RAs B, C, and D)

Ancillary Sitewide Actions

5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)	$15,000
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)	$15,000
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)	$15,000
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)	$15,000
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)	$15,000
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)	$50,000

Soil Remedial Alternative 4
FMC Pocatello Idaho, LLC.

Soil Remedial Alternative 4			
Key Assumptions: Capital Costs in 2009 dollars. Annual O&M costs in 2009 dollars. All caps will require 3% slope. 5% of construction costs was assumed for stormwater management. The SRI borings adequately chacterized depth of fill RA A. All ET caps consist of 24 inches of cover. All required cover soil for caps available onsite from Western Borrow Area Assume 3,000,000 yd3 for grading of slag pile including backfilling of valley down center of slag pile. All fill for grading and capillary break will be obtain onsite from crushed slag sources.			
RA A Specific Remedial Costs	**Capital Cost 2009 Dollars**	**O&M Costs 2009 Dollars**	**NPV**
RA-A			
1.Removal and Consolidation (assuming 7.4 feet removal average depth)	$27,480,400		$27,480,400
2.Hydrocarbon Soil Removal	$19,001		$19,001
Subtotal RA A	**$27,500,000**	**$0**	**$27,500,000**
RA-B			
1. Grade to 3%	$47,000		$47,000
2. ET cap	$1,011,670		$1,011,670
3. PH3 Monitoring Probe Installation	$3,000		$3,000
4. Institutional Controls (Costs captured as part of environmental controls)			
5.Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$13,200	$34,637
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$21,900	$271,753
Subtotal RA B	**$1,062,000**	**$36,000**	**$1,369,000**
RA-C			
1. Grade to 3%	$112,800		$112,800
2. ET cap	$3,235,100		$3,235,100
3. PH3 Monitoring Probe Installation	$8,000		$8,000
4. Institutional Controls (costs captured as part of environmental controls)			
5.Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$35,200	$92,365
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$70,030	$869,007
Subtotal RA C	**$3,356,000**	**$106,000**	**$4,318,000**
RA-D			
1. Grade to 3%	$940,000		$940,000
2.Hurricane Fence (costs captured as part of environmental controls)	$0		$0
3. ET Cap	$3,142,535		$3,142,535
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$68,027	$844,143
Subtotal RA D	**$4,083,000**	**$69,000**	**$4,927,000**
RA-E			
1. Grade to 3%	$47,000		$47,000
2. ET Cap	$1,982,200		$1,982,200
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$42,909	$532,455
Subtotal RA E	**$2,030,000**	**$43,000**	**$2,562,000**
RA-F			
1. Grade to 3:1 slope	$5,640,000		$5,640,000
2. Gamma Cap	$4,267,120		$4,267,120
3. ET Cap	$2,038,300		$2,038,300
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$94,050	$1,167,066
Subtotal RA F	**$11,946,000**	**$95,000**	**$13,113,000**
RA-G			
1. Grade to 3% slope	$47,000		$47,000
2. Gamma Cap	$1,881,880		$1,881,880
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$36,190	$449,082
Subtotal RA G	**$1,929,000**	**$37,000**	**$2,378,000**
RA-H			
1. Grade to 3% slope	$9,400		$9,400
2. ET Cap	$1,636,250		$1,636,250
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$35,420	$439,527
Subtotal RA H	**$1,646,000**	**$36,000**	**$2,086,000**
RA-J			
2. Excavation and Consolidation (6-inches)	$375,000		$375,000
Subtotal RA J	**$375,000**	**$0**	**$375,000**
RA-K			
1. Excavate and Consolidate	$186,000		$186,000
Subtotal RA K	**$186,000**	**$0**	**$186,000**
Storm Sewer Piping			
1.Clean and Treat Offsite	$27,672		$27,672
Subtotal Sewer Piping	**$28,000**	**$0**	**$28,000**
Ancillary Sitewide Actions			
Ancillary Sitewide Actions			
Seal all non-P4 piping/conduits exiting ET caps	$500,000		$500,000
Mob/Demob (1% of construction costs)	$541,410		$541,410
Stormwater Management (5% of construction costs)	$2,707,050		$2,707,050
Environmental Controls (10% construction costs)	$5,414,100		$5,414,100
Subtotal Ancillary Sitewide Actions	**$9,163,000**	**$0**	**$9,163,000**
Reporting and Engineering			
Engineering Design (10% of construction costs)	$5,414,100		$5,414,100
Construction Management (15% of construction costs)	$8,121,150		$8,121,150
5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)		$15,000	$12,939
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)		$15,000	$11,161
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)		$15,000	$9,628
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)		$15,000	$8,305
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)		$15,000	$7,164
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)		$50,000	$20,599
Subtotal Engineering and Reporting	**$13,536,000**	**$125,000**	**$13,606,000**
Total Cost	**76,840,000.00**	**547,000.00**	**81,611,000.00**

ASSUMPTIONS AND CALCULATIONS
Unit Rates

Item	Cost	Unit	Cost Backup
Fencing	NA	ft	Costs captured as part of environmental controls.
ET Capping	$85,000.00	acre	Table 2
Gamma Capping	$26,000.00	acre	Table 3
Rough Site Grading	$1.88	CY	2009 RS Means 31.23.23.17 0011
PH3 Monitoring Installation	$1,000.00	acre	Engineering Assumption
Remove and Consolidate RA A	$266,800.00	acre	Table 6
Remove and Consolidate Hydrocarbon Impacted Soil	$19,001.00	LS	Table 9
Remove and Consolidate RA K	$186,000.00	LS	Table 7
Scrape RA-J	$25,000.00	acre	Table 5
Clean and Treat Storm Sewer Piping	$300.00	ft	Table 4
O&M for gamma caps	$500.00	acre/yr	Table 13
Annual PH3 Monitoring	$4,400.00	location	Table 15
O&M for Caps	$1,840.00	acre/yr	Table 14

RA-A

General Assumptions:	Acres
Acreage	103
Excavate and Consolidate RA A down to 7.4 feet	103
Remove Hydrocarbon Impacted Soil	

Costing Calculations	Unit Cost	# Units	Units	Total
Excavate and Consolidate	$266,800	103	acres	$27,480,400
Hydrocarbon Impacted Soil Removal	$19,001	1	LS	$19,001

RA-B

General Assumptions:	Acres	Cap Boundary
Acreage	10.82	11.902

PH3 monitoring required for first three years only.
ET Cap

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (Costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	11.902	acre	$1,011,670
PH3 Monitoring Installation	$1,000.00	3	location	$3,000
Annual PH3 Monitoring	$4,400.00	3	location	$13,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	11.902	acre	$21,900

RA-C

General Assumptions:	Cap Boundary
Acreage	34.6 38.06

PH3 monitoring required for first three years only.
ET cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (Costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	60000	CY	$112,800
ET Cap	$85,000.00	38.06	acre	$3,235,100
PH3 Monitoring Installation	$1,000.00	8	location	$8,000
Annual PH3 Monitoring	$4,400.00	8	location	$35,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	38.06	acre	$70,030

RA-D

General Assumptions:	Cap Boundary
Acreage	33.61 36.971

ET Cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane Fence (Costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	500000	CY	$940,000
ET Cap	$85,000.00	36.971	acre	$3,142,535
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	36.971	acre	$68,027

RA-E

General Assumptions:	Cap Boundary
Acreage	21.2 23.32

ET cap
Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	23.32	acre	$1,982,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	23.32	acre	$42,909

RA-F

General Assumptions:	Acres	Cap Boundary
RA Acreage	171	188.1
Gamma Cap	149.2	164.12
ET cap over burried railroad cars and 19b	21.8	23.98

Site requires re-grading to establish minium 1% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading to 3:1 slope	$1.88	3000000	CY	$5,640,000
ET Cap	$85,000.00	23.98	acres	$2,038,300
Gamma Cap	$26,000.00	164.12	acre	$4,267,120
Annual O&M (includes cap integrity monitoring and repair)	$500.00	188.1	yr	$94,050

Remedial Alternative 4
RA Cost Estimates And Assumptions

RA-G

General Assumptions:	Acres	Cap Boundary
Acreage	65.8	
Gamma Cap	65.8	72.38

Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
Gamma Cap	$26,000.00	72.38	acre	$1,881,880
Annual O&M (includes cap integrity monitoring and repair)	$500.00	72.38	acre	$36,190

RA-H

General Assumptions:		Cap Boundary
Acreage	17.5	19.25
ET cap		

Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	5000	CY	$9,400
ET Cap	$85,000.00	19.25	acre	$1,636,250
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	19.25	acre	$35,420

RA-I

General Assumptions:	
Acerage	191
Receptor-initiated remediation	

Costing Calculations	Unit Cost	# Units	Units	Total
Annual O&M	$500.00	118	acre	$59,000

RA-J

General Assumptions:		
Acerage	15	Cap Boundary
Excavation and Consolidation	15	

Costing Calculations	Unit Cost	# Units	Units	Total
Excavation and Consolidation (6-inches)	$25,000	15	acre	$375,000

RA-K

General Assumptions:	
Acerage	1.3
Excavate and Consolidate	

Costing Calculations	Unit Cost	# Units	Units	Total
Excavate and Consolidate	$186,000	1	LS	$186,000

Storm Sewer Piping

General Assumptions:	
Linear Feet	92.24
Clean in Place and Treat OffSite	

Costing Calculations	Unit Cost	# Units	Units	Total
Clean and treat Offsite	$300	92.24	ft	$27,672

Ancillary Sitewide Actions

5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)	$15,000	$10,695.000
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)	$15,000	$7,620.000
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)	$15,000	$5,430.000
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)	$15,000	$3,870.000
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)	$15,000	$2,760.000
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)	$50,000	$6,550.000

Soil Remedial Alternative 5

Key Assumptions:
Capital Costs in 2009 dollars.
Annual O&M costs in 2009 dollars.
No costs incurred for future receptor initiated remediation.
All caps will require 3% slope.
5% of construction costs was assumed for stormwater management.
Groundwater monitoring is captured in groundwater cost spreadsheet
All ET covers assumes 24 inches of soil as presented in Section 4 of the Cap Memorandum (June, 2009).
All required cover soil for caps available onsite from Western Borrow Area.
Assume 3,000,000 yd3 for grading of slag pile including backfilling of valley down center of slag pile.
All fill for grading and capillary break will be obtain onsite from crushed slag sources.

RA Specific Remedial Costs	Capital Cost 2009 Dollars	Annual O&M Cost 2009 Dollars	NPV
RA-A			
1.Removal and Consolidation	$27,480,400		$27,480,400
2.Hydrocarbon Soil Removal and Treat On-site	$321,136		$321,136
Subtotal RA A	**$27,802,000**		**$27,802,000**
RA-B			
1. Grade to 3%	$47,000		$47,000
2.Excavate and treat	$14,371,600		$14,371,600
3. ET Cap	$1,011,670		$1,011,670
4. PH3 vapor/PH3 Monitoring Probe Installation	$3,000		$3,000
5. Institutional Controls (Costs captured as part of environmental controls)			
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$21,900	$271,753
7. Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$13,200	$34,637
Subtotal RA B	**$15,434,000**	**$36,000**	**$15,740,000**
RA-C			
1. Grade to 3%	$112,800		$112,800
2.Excavate and treat	$14,410,000		$14,410,000
3. ET cap	$3,234,165		$3,234,165
4. PH3 vapor/PH3 Monitoring Probe Installation	$8,000		$8,000
5. Institutional Controls (Costs captured as part of environmental controls)			
6. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$70,010	$868,756
7. Annual PH3 Monitoring (NPV assumes a 3 year discount rate at 7% of 2.624)		$35,200	$92,365
Subtotal RA C	**$17,765,000**	**$106,000**	**$18,727,000**
RA-D			
1. Institutional Controls (Costs captured as part of environmental controls)			$0
2. Grade to 3%	$940,000		$940,000
3. Construct ET Cap	$3,142,535		$3,142,535
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$68,027	$844,143
Subtotal RA D	**$4,083,000**	**$69,000**	**$4,927,000**
RA-E			
1. Grade to 3%	$47,000		$47,000
2. Construct ET cap	$1,982,200		$1,982,200
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$42,909	$532,455
Subtotal RA E	**$2,030,000**	**$43,000**	**$2,562,000**
RA-F			
1. Grade to 3:1 slope	$5,640,000		$5,640,000
2. Gamma Cap	$4,267,120		$4,267,120
3. ET Cap	$2,038,300		$2,038,300
4. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$94,050	$1,167,066
Subtotal RA F	**$11,946,000**	**$95,000**	**$13,113,000**
RA-G			
1. Grade to 3% slope	$47,000		$47,000
2. Construct Gamma Cap	$1,881,880		$1,881,880
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$36,190	$449,082
Subtotal RA G	**$1,929,000**	**$37,000**	**$2,378,000**
RA-H			
1. Grade to 3% slope	$9,400		$9,400
2. Construct ET Cap	$1,636,250		$1,636,250
3. O&M (NPV assumes a 30 year discount rate at 7% of 12.409)		$35,420	$439,527
Subtotal RA H	**$1,646,000**	**$36,000**	**$2,086,000**
RA-I			
1. Exacavte and consolidate to 1 foot	$9,550,000		$9,550,000
Subtotal RA I	**$9,550,000**	**$0**	**$9,550,000**
RA-J			
1. Excavate and consolidate to 1 foot	$800,000		$800,000
Subtotal RA J	**$800,000**	**$0**	**$800,000**
RA-K			
1. Remove and Treat	$218,000		$218,000
Subtotal RA K	**$218,000**		**$218,000**
1.Construct LDR Treatment System			
LDR System	$150,000,000		$150,000,000
Feed Mill	$2,000,000		$2,000,000
Subtotal LDR System	**$152,000,000**		**$152,000,000**
Ancillary Sitewide Actions			
Seal all non-P4 piping/conduits exiting ET caps	$500,000		$500,000
Electricity for LDR System(NPV assumes a 30 year discount rate at 7% of 12.409)		$2,666,000	$33,083,000
O&M for LDR System ((NPV assumes a 30 year discount rate at 7% of 12.409)		$1,278,000	$15,859,000
Mob/Demob (1% of Construction Costs)	$2,453,000		$2,453,000
Stormwater Management (5% of construction costs)	$12,261,000		$12,261,000
Environmental Controls (10% construction costs)	$41,937,000		$41,937,000
Subtotal Ancillary Sitewide Actions	**$57,151,000**	**$3,944,000**	**$106,093,000**
Reporting and Engineering			
Engineering Design (10% of construction costs)	$24,521,000		$24,521,000
Construction Management (15% of construction costs)	$24,521,000		$24,521,000
5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)		$15,000	$12,939
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)		$15,000	$11,161
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)		$15,000	$9,628
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)		$15,000	$8,305
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)		$15,000	$7,164
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)		$50,000	$20,599
Subtotal Engineering and Reporting	**$49,042,000**	**$125,000**	**$49,111,797**

Total Cost	**$353,042,000**	**$4,491,000**	**$405,108,000**

Soil Remedial Alternative 5
RA Cost Estimates And Assumptions

ASSUMPTIONS AND CALCULATIONS
Unit Rates

Item	Cost	Unit	Cost Backup
Fencing	NA	ft	Costs captured as part of environmental controls
ET Capping	$85,000.00	acre	Table 2
Gamma Capping	$26,000.00	acre	Table 3
Rough Site Grading	$1.88	CY	2009 RS Means 31.23.23.17 0011
PH3 Monitoring Installation	$1,000.00	location/1000ft	Engineering Assumtpion
Remove and Consolidate RA A	$266,800.00	acre	Table 6
Remove and Treat Hydrocarbon Impacted Soil	$321,136.00	LS	Table 10
Excavate and On-Site Treat Railroad Swale	$218,000.00	LS	Table 8
Excavate and On-Site Treat RA B	$1,891,000.00	acre	Table 11
Excavate and On-Site Treat RA C	$655,000.00	acre	Table 12
Exacavate and consolidate RA I and J to 1 foot	$50,000.00	acre	Table 5 doubled
Clean Stormwater and Process Piping	$300.00	ft	Table 4
Annual PH3 Monitoring	$4,400.00	location	Table 15
O&M for Gamma caps	$500.00	acre/yr	Table 13
O&M for Caps	$1,840.00	acre/yr	Table 14

RA-A

General Assumptions:	Acres	Cap Boundary
RA Acres	103	
Remove and Consolidate RA A down to 6 feet		
Remove Hydrocarbon Impacted Soil		

Costing Calculations	Unit Cost	# Units	Units	Total
Excavate and Consolidate	$266,800	103	acres	$27,480,400
Hydrocarbon Impacted Soil Removal	$321,136	1	LS	$321,136

RA-B

General Assumptions:	Acres	Cap Boundary
Acreage	10.82	11.902
Excavate and treat top 10 feet ofsoil /fill. (assumes native soils is overlain by 5 feet of slag and concrete).	7.6	
PH3 monitoring required for first three years only.		
ET cap		

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (Costs captured as part of environmental controls)				
Excavate and treat soil overlying material	$1,891,000.00	7.6	acre	$14,371,600
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	11.902	acre	$1,011,670
PH3 Monitoring Installation	$1,000.00	3	location	$3,000
Annual PH3 Monitoring	$4,400.00	3	location	$13,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	11.902	acre	$21,900

RA-C

General Assumptions:		Cap Boundary
Acreage	34.59	38.049
PH3 monitoring required for first three years only.		
Excavate and treat top 10 feet of native soil . (assumes native soils is overlain by 10 feet of slag).	22	
ET Cap		
Site requires re-grading to establish minium 3% slope		

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane fence (Costs captured as part of environmental controls)				
Exacavate and treat soil	$655,000.00	22	acres	$14,410,000
Rough Grading of Subgrade to 3%	$1.88	60000	CY	$112,800
ET Cap	$85,000.00	38.049	acre	$3,234,165
PH3 Monitoring Installation	$1,000.00	8	location	$8,000
Annual PH3 Monitoring	$4,400.00	8	location	$35,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	38.049	acre	$70,010.16

RA-D

General Assumptions:		Cap Boundary
Acreage	33.61	36.971
ET cap		
Remove underground piping		
Site requires re-grading to establish minium 3% slope		

Costing Calculations	Unit Cost	# Units	Units	Total
Hurricane Fence (Costs captured as part of environmental controls)				
Rough Grading of Subgrade to 3%	$1.88	500000	CY	$940,000
ET Cap	$85,000.00	36.971	acre	$3,142,535
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	36.971	acre	$68,026.64

RA-E

General Assumptions:		Cap Boundary
Acreage	21.2	23.32
ET Cap		
Site requires re-grading to establish minium 3% slope		

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
ET Cap	$85,000.00	23.32	acre	$1,982,200
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	23.32	acre	$42,909

RA-F

General Assumptions:	Acres	Cap Boundary
RA Acreage	171	188.1
Gamma Cap	149.2	164.12
ET cap over 19b and Railcars	21.8	23.98
Site requires re-grading to establish minium 1% slope		

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading to 3:1 slope	$1.88	3000000	CY	$5,640,000
ET Cap	$85,000.00	23.98	acres	$2,038,300
Gamma Cap	$26,000.00	164.12	acre	$4,267,120
Annual O&M (includes cap integrity monitoring and repair)	$500.00	188.1	yr	$94,050.00

Soil Remedial Alternative 5
RA Cost Estimates And Assumptions

RA-G

General Assumptions:	Acres	Cap Boundary
Acreage	65.8	
Gamma Cap	65.8	72.38

Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	25000	CY	$47,000
Gamma Cap	$26,000.00	72.38	acre	$1,881,880
Annual O&M (includes cap integrity monitoring and repair)	$500.00	72.38	acre	$36,190.00

RA-H

General Assumptions:		Cap Boundary
Acreage	17.5	19.25
ET cap		

Site requires re-grading to establish minium 3% slope

Costing Calculations	Unit Cost	# Units	Units	Total
Rough Grading of Subgrade to 3%	$1.88	5000	CY	$9,400
ET Cap	$85,000.00	19.25	acre	$1,636,250
Annual O&M (includes cap integrity monitoring and repair)	$1,840.00	19.25	acre	$35,420.00

RA-I

General Assumptions:

Acerage 191

Access restrictions

Costing Calculations	Unit Cost	# Units	Units	Total
Exacavte and consolidate	$50,000.00	191	acre	$9,550,000.00

RA-J

General Assumptions:

Acerage 16

8-ft hurricane fence for access control arounf landfill.

Costing Calculations	Unit Cost	# Units	Units	Total
Exacavate and consolidate	$50,000	16	acre	$800,000

RA-K

General Assumptions:

Acerage 1.3

Excavate and treat on-site

Costing Calculations	Unit Cost	# Units	Units	Total
Excavate and treat on-site	$218,000.00	1	LS	$218,000.00

Stormsewer Piping

General Assumptions:

Stormsewer piping would be addressed as part of removal of RA-A

Process Piping

General Assumptions:

Process piping would be addressed as part of removal of RA-B and C

P4 Soil Conveyance and Treatment Capital Costs

a. P4 LDR Treatment System (cost obtained from FMC LDR system)	$150,000,000.00	1.00 LS	$150,000,000.00
b. Feed Mill	$2,000,000.00	1.00 LS	$2,000,000.00
Annual O&M Costs for P4 treatment System			
Electricity for Pumps	$0.68	1,306,466.00 Kw/h	$888,396.88
Electricity for LDR System	$0.68	3,919,399.00 Kw/h	$2,665,191.32
O&M for LDR System	$3,500.00	$365.00 day	$1,277,500.00
5 year Review (NPV assumes discount factor of 0.713 for 7% discount rate)		$15,000	$10,695.000
10 year Review(NPV assumes discount factor of 0.508 for 7% discount rate)		$15,000	$7,620.000
15 Year Review(NPV assumes discount factor of 0.362 for 7% discount rate)		$15,000	$5,430.000
20 Year Review(NPV assumes discount factor of 0.258 for 7% discount rate)		$15,000	$3,870.000
25 Year Review(NPV assumes discount factor of 0.184 for 7% discount rate)		$15,000	$2,760.000
30 Year Review and Closure Report(NPV assumes discount factor of 0.131 for 7% discount rate)		$50,000	$6,550.000

Table 1
Unit Rates for Remedial Actions

Item Description	Unit	Unit Cost ($)	Comment
Fence materials and installation	LF	$49	2009 Means 32 31 13.20. 0940 8' high, 6 ga wire, 2.5" line posts, galv. Steel, in concrete
Load capillary break materials (6 inches thick) for ET cap construction.	CY	$0.46	2009 Means 31 23 23.15 5080. Granular fill assuming onsite source.
Haul capillary break materials for ET cap construction.	CY	$5.00	2009 Means 31 23 23.20 5340. One mile round trip
Spread capillary break Soils with Dozer, no compaction for ET cap construction.	CY	$1.88	2009 Means 31 23 23.17 0020
Strip and Stockpile native soil (assume 1.3 bulking factor for 2 feet thick cover)	CY	$2.18	2009 Means 31 14 13.23 1420
Load fill materials for soil layer for all caps.	CY	$1.22	2009 Means 31 23 23.15 7020. Front end loader, loam or top soil assuming on-site source.
Haul fill materials for caps	CY	$5.00	2009 Means 31 23 23.20 5340. One mile round trip
Spread cover soils with Dozer, no compaction for caps	CY	$1.88	2009 Means 31 23 23.17 0020
Revegetation for caps and/or bare soil.	acre	$3,600.00	From current project
Clean Piping In Place	LF	$1.00	Engineers Estimate
Containerize in 55 gallon Drums	gallons	$1	Assuming avergage diameter of 12 inches and 10 pipe volumes. Assuming $60 per drum.
Transport to Clean Harbors Facility in El Dorado, AR	tons	$30.00	Quote from TW Company.
Dispose of water at Clean Harbors in El Dorado, AR.	lbs	$0.50	Preliminary Quote from Clean Harbors.
Scrape slag to 6 inch in Northern Properties.	CY	$1.94	2009 Means 31 14 16.43 .6200
Rip slag to 7.4 feet in RA-A	CY	$3.54	2009 Means 31 23 16.32 .2600
Excavate ripped slag and soil in RA-A	CY	$1.37	2009 RS Means 31.23.16.42 0305
Excavate overburden assuming 8 feet below ground surface in RA-K	CY	$2.68	5 foot wide trench. 2009 RS Means 31 23.16.13 0620
Excavate impacted P4 soil to 2 feet at RA-K.	CY	$3.75	5 foot wide trench. 2009 RS Means 31 23.16.13 0620 iincreased by 40% for Level A.
Transport P4 soils to RA-B from RA-K.	CY	$5.00	2009 Means 31 23 23.20 5340. One mile round trip
Transport P4 soil to treatment unit from RA-K.	CY	$5.00	2009 Means 31 23 23.20 5340. One mile round trip
Prepare feed in crusher and treat for P4 soils.	CY	$5.00	Engineering Estimate
Transportation and placement of hydrocarbon soils from RA-A to RAs B, C, or D	CY	$3.15	2009 Means 31 23 23.20 8320
Excavate slag, concrete, assuming 5 feet below ground surface at RA-B for treatment.	CY	$191.00	2009 RS Means 03 05 05.10 0060 increased by 40% for Level A.
Excavate soil and P4 down to 5 feet	CY	$11.41	2009 RS Means 31.23 16.42 1800 increased by 40% for Level A
Place removed material in roll-off bin with Water	CY	$10.00	Engineering Estimate. Quantity assumes that 20% of volume requires treatement.
Transport to treatment unit	CY	$7.00	2009 Means 31 23 23.20 5340. One mile round trip increased by 40% for Level A
Gamma Cap Base O&M	acre	$500.00	Annual O&M/repair for reseeding, fence repair, sign repair, etc. Quote from current O&M contractor (A&E Engineering, Inc.).
Settlement Monitoring and Reporting	acre/cycle	$135	Quote from current O&M contractor (A&E Engineering, Inc.).
Cap Drainage Maintenance	acre/cycle	$120	Quote from current O&M contractor (A&E Engineering, Inc.).
Erosion Monitoring and Repair	acre/cycle	$80	Quote from current O&M contractor (A&E Engineering, Inc.).
PH3 Perimeter Monitoring	1000 ft/cycle	$1,100.00	Current cost for P4 vapor and PH3 perimeter monitoring of ET caps / multilayered RCRA ponds. Cost based on $ per 100 feet of cap per cycle. Quote from current O&M contractor (A&E Engineering, Inc.).

Table 2
COST ESTIMATE FOR EVAPOTRANSPIRATIVE CAP

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
	Construction of 2-Ft Soil Cover						
1	Load capillary break materials (6 inches thick)		1613	cy	$0.46	$742	2009 Means 31 23 23.15 5080. Granular fill assuming onsite source.
2	Haul capillary break materials		1613	cy	$5.00	$8,065	2009 Means 31 23 23.20 5340. One mile round trip
3	Spread capillary break Soils with Dozer, no compaction		1613	cy	$1.88	$3,032	2009 Means 31 23 23.17 0020
4	Strip and Stockpile native soil (assume 1.3 bulking factor for 2 feet thick cove		4194	cy	$2.18	$9,143	2009 Means 31 14 13.23 1420
5	Load fill materials for soil layer		4194	cy	$1.22	$5,117	2009 Means 31 23 23.15 7020. Front end loader, loam or top soil assuming on-site source.
6	Haul fill materials		4194	cy	$5.00	$20,970	2009 Means 31 23 23.20 5340. One mile round trip
7	Spread cover soils with Dozer, no compaction		4194	cy	$1.88	$7,885	2009 Means 31 23 23.17 0020
8	Revegetation		1	acre	$3,600	$3,600	From current project
		Subtotal Capital Costs				**$85,000**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table3
COST ESTIMATE FOR GAMMA CAP

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
	Construction of 1-Ft Soil Cover						
1	Strip and Tockpile native soil (assuming 1.3 bulking factor)		2097	cy	$2.18	$4,571	2009 Means 31 14 13.23 1420
2	Load fill materials for soil layer		2097	cy	$1.22	$2,558	2009 Means 31 23 23.15 3020. Front end loader, loam or top soil assuming on-site source.
3	Haul fill materials		2097	cy	$5.00	$10,485	2009 Means 31 23 23.20 5340. One mile round trip
4	Spread cover soils with Dozer, no compaction		2097	cy	$1.88	$3,942	2009 Means 31 23 23.17 0020
5	Revegetation		1	acre	$3,600	$3,600	From current project
	Subtotal Capital Costs					**$26,000**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 4
COST ESTIMATE FOR CLEANING OF SEWER PIPING

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	DIRECT CAPITAL COSTS						
1	Clean Piping In Place		1	LF	$1	$1	
2	Containerize in 55 gallon Drums		55	gallons	$1.09	$60	Assuming avergage diameter of 12 inches and 10 pipe volumes. Assuming $60 per drum.
3	Transport to Clean Harbors		0.229	tons	$30.00	$7	Quote from TW Company.
4	Dispose of water at Clean Harbors		458	lbs	$0.50	$229	Preliminary Quote from Clean Harbors.
					Subtotal Capital Costs	**$297**	
	TOTAL CAPITAL COSTS					**$300**	Does not include subcontractor mark-up or profit

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 5
COST ESTIMATE FOR REMOVAL AND CONSOLIDATION OF RA J

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
	Excavate Contaminated Soils for On-site Consolidation						
1	Scrape slag to 6 inch		806	cy	$1.94	$1,564	2009 Means 31 14 16.43 .6200
2	Load slag into trucks		806	cy	$0.46	$371	2009 Means 31 23 23.15 5080. Granular fill assuming onsite source.
3	Transportation and placement of soils at existing slag piles		806	cy	$5.00	$4,030	2009 Means 31 23 23.20 5340. One mile round trip
					Subtotal Capital Costs	**$25,000**	

Notes:
1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002)

Table 6
COST ESTIMATE FOR REMOVAL AND CONSOLIDATION OF RA A

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
1	Rip slag to 7.4 feet		11938	bcy	$3.54	$42,261	2009 Means 31 23 16.32 .2600
2	Load slag into trucks		11938	cy	$0.46	$5,491	2009 Means 31 23 23.15 5080. Granular fill assuming onsite source.
3	Transportation and placement of soils at existing slag piles		11938	cy	$5.00	$59,690	2009 Means 31 23 23.20 5340. One mile round trip
	Site Restoration						
4	Strip and Stockpile native soil		11938	cy	$2.18	$26,025	2009 Means 31 14 13.23 1420
5	Load fill materials for soil layer		11938	cy	$1.22	$14,564	2009 Means 31 23 23.15 7020. Front end loader, loam or top soil assuming on-site source.
6	Haul fill materials		11938	cy	$5.00	$59,690	2009 Means 31 23 23.20 5340. One mile round trip
7	Spread cover soils with dozer		11938	cy	$1.88	$22,443	2009 Means 31 23 23.17 0020
8	Revegetation		1	acre	$3,600.00	$3,600	From current project
				Subtotal Capital Costs		**$266,800**	

Notes:
1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002)

Table7
COST ESTIMATE FOR REMOVAL AND CONSOLIDATION OF RAILROAD SWALE

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	DIRECT CAPITAL COSTS						
	Excavate Contaminated Soils for On-site Consolidation						
1	Ripping of overburden		16778	bcy	$3.54	$59,394	5 foot wide trench. 2009 RS Means 31 23.16.32 2600
3	Excavate overburden assuming 8 feet below ground surface		16778	bcy	$2.68	$44,965	5 foot wide trench. 2009 RS Means 31 23.16.13 0620
4	Excavate impacted P4 soil to 2 feet.		4194	bcy	$3.75	$15,728	5 foot wide trench. 2009 RS Means 31 23.16.13 0620 iincreased by 40% for Level A.
5	Transport to RA-B		4194	bcy	$5.00	$20,970	2009 Means 31 23 23.20 5340. One mile round trip
	Site Restoration						
6	Strip and Stockpile Native Soil		4194	cy	$2.18	$9,143	2009 Means 31 23 13.23 1420
7	Load materials for soil layer		4194	cy	$0.60	$2,516	2009 Means 31 23 23.15 6050
8	Haul fill materials		4194	cy	$5.00	$20,970	2009 Means 31 23 23.20 5340
9	Spread cover soils with dozer		4194	cy	$1.88	$7,885	2009 RS Means 31 23 23.17 0020
10	Revegetation		1	acre	$3,600.00	$3,600	From current project
				Subtotal Capital Costs		**$186,000**	
	TOTAL CAPITAL COSTS					**$186,000**	Does not include subcontractor mark-up or profit

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 8
COST ESTIMATE FOR REMOVAL AND ON-SITE TREATMENT OF RAILROAD SWALE

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	DIRECT CAPITAL COSTS					
	Direct Capital Costs					
	Excavate Contaminated Soils for On-site Consolidation					
1	Rip overburden assuming 8 feet below ground surface	16778	bcy	$3.54	$59,394	5 foot wide trench. 2009 RS Means 31 23.16.32 2600
2	Excavate ripped slag	16778	bcy	$1.37	$22,986	2009 RS Means 31.23.16.42 0305
3	Excavate impacted P4 soil to 2 feet.	4194	bcy	$3.75	$15,728	5 foot wide trench. 2009 RS Means 31 23.16.13 0620 increased by 40% for Level A.
4	Place in roll-off bin with Water	4194	bcy	$3.75	$15,728	5 foot wide trench. 2009 RS Means 31 23.16.13 0620 increased by 40% for Level A.
5	Transport to treatment unit	4194	bcy	$5.00	$20,970	2009 Means 31 23 23.20 5340. One mile round trip
6	Prepare feed in crusher and treat	4194	bcy	10.00	$41,940	Engineering Estimate
	Site Restoration					
6	Strip and Stockpile Native Soil	4194	cy	$2.18	$9,143	2009 Means 31 23 13.23 1420
7	Load materials for soil layer	4194	cy	$0.60	$2,516	2009 Means 31 23 23.15 6050
8	Haul fill materials	4194	cy	$5.00	$20,970	2009 Means 31 23 23.20 5340
9	Spread cover soils with dozer	4194	cy	$1.88	$7,885	2009 RS Means 31 23 23.17 0020
10	Revegetation	1	acre	$3,600.00	$3,600	From current project
			Subtotal Capital Costs		**$217,259**	
	TOTAL CAPITAL COSTS				**$218,000**	Does not include subcontractor mark-up or profit

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 9
COST ESTIMATE FOR REMOVAL AND CONSOLIDATION OF HYDROCARBON SOIL FOR ALTERNATIVE 4

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
1	**DIRECT CAPITAL COSTS**						
	Excavate Contaminated Soils for On-site Consolidation						
		Excavate Hydrocarbon Impacted Soil	4205	cy	$1.37	$5,761	2009 Means 31 23 16.42 .0305
		Transportation and placement of soils at RAs B, C, or D	4205	cy	$3.15	$13,246	2009 Means 31 23 23.20 8320
					Subtotal Capital Costs	**$19,007**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 10
COST ESTIMATE FOR LANDFARMING OF HYDROCARBON SOIL FOR ALTERNATIVE 5

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
1	**DIRECT CAPITAL COSTS**						
Assume 2 areas of 200 and 400 foot diameter to a depth of 2 feet +2 feet of overlying slag							
		Excavate Hydrocarbon Impacted Soil	4205	cy	$1.37	$5,761	2009 Means 31 23 16.42 0305
		On-Site Landfarming of Hydrocarbon Impacted Soil	4205	cy	$75.00	$315,375	http://www.frtr.gov/matrix2/section4/4_13a.html
				Subtotal Capital Costs		**$321,136**	

Table 11
COST ESTIMATE FOR REMOVAL of RA B

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	DIRECT CAPITAL COSTS						
	Excavate Contaminated Soils for On-site Treatment						
1	Excavate slag, concrete, assuming 5 feet below ground surface		8066	bcy	$191.00	$1,540,606	2009 RS Means 03 05 05.10 0060 increased by 40% for Level A.
2	Excavate soil and P4 down to 10 feet		16,133	bcy	$11.41	$184,078	2009 RS Means 31.23 16.42 1800 increased by 40% for Level A
3	Place removed material in roll-off bin with Water		3,226	bcy	$10.00	$32,260	Engineering Estimate. Quantity assumes that 20% of volume requires treatement.
4	Transport to treatment unit		3,226	bcy	$7.00	$22,582	2009 Means 31 23 23.20 5340. One mile round trip increased by 40% for Level A
5	Prepare feed in crusher		3,226	bcy	$10.00	$32,260	Engineering Estimate
	Site Restoration						
6	Excavate and load bulk bank measure from slag pit		3226	cy	$2.05	$6,613	2009 Means 31 23 16.42 1350
7	Backfill Excavated Area		16133	cy	$3.77	$60,821	2009 Means 31 23 23.17 0190
8	Haul fill materials		3226	cy	$3.39	$10,936	2009 Means 31 23 23.20 8340
					Subtotal Capital Costs	**$1,890,156**	
	TOTAL CAPITAL COSTS					**$1,891,000**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 12
COST ESTIMATE FOR REMOVAL of RA C

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	DIRECT CAPITAL COSTS					
	Excavate Contaminated Soils for On-site Treatment					
1	Excavate slag overburden assuming 10 feet below ground surface	16133	bcy	3.58	$57,756	2009 RS Means 31 23.16.13 0620 increased by 40% for Level A.
2	Excavate 10 feet of P4 impacted soil	16133	bcy	11.41	$184,078	2009 RS Means 31.23 16.42 1800 increased by 40% for Level A
3	Place removed material in roll-off bin with Water	16133	bcy	10.00	$161,330	Engineering Estimate
4	Transport to treatment unit	16133	bcy	5.56	$89,699	2009 Means 31 23 23.20 5340. One mile round trip increased by 40% for Level A
5	Prepare feed in crusher and treat	16133	bcy	10.00	$161,330	Engineering Estimate
	Site Restoration					
6	Excavate and load bulk bank measure from slag pit.	16133	cy	$2.05	$33,073	2009 Means 31 23 16.42 1350
7	Backfill Excavated Area	32266	cy	$3.77	$121,643	2009 Means 31 23 23.17 0190
8	Haul fill materials	16133	cy	$5.00	$80,665	2009 Means 31 23 23.20 5340
			Subtotal Capital Costs		**$654,193**	
	TOTAL CAPITAL COSTS				**$655,000**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 13
Base O&M Costs

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
	Base O&M Costs						
1	Gamma Cap Base O&M		1	acre/year	$500.00	$500	Annual O&M/repair for vegetation reseeding, erosion repairs, fence repair, sign repair, etc. Quote from current O&M contractor (A&E Engineering, Inc.).
	Subtotal Capital Costs					**$500**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 14
Cap O&M Costs

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
	Cap O&M Costs						
1	Base O&M		1	acre/year	$500.00	$500	Annual O&M/repair for vegetation reseending, erosion repiars, fence repair, sign repir, etc. Quote from current O&M contractor (A&E Engineering, Inc.).
2	Settlement Monitoring and Reporting		4	acre/cycle	$135	$540	Quote from current O&M contractor (A&E Engineering, Inc.).
3	Vegetation Monitoring and Reporting		4	acre/cycle	$120	$480	Quote from current O&M contractor (A&E Engineering, Inc.).
4	Erosion Monitoring and Repair		4	acre/cycle	$80	$320	Quote from current O&M contractor (A&E Engineering, Inc.).
		Subtotal Capital Costs				**$1,840**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Table 15
P4 Monitoring Costs

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	Direct Capital Costs						
	P4 Monitoring Costs						
1	PH3 Perimeter Monitoring		4	1000 ft/cycle	$1,100.00	$4,400	Current cost for P4 vapor and PH3 perimeter monitoring of ET caps / multilayered RCRA ponds. Cost based on $ per 100 feet of cap per cycle. Quote from current O&M contractor (A&E Engineering, Inc.).
	Subtotal Capital Costs					**$4,400**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002).

Summary of Groundwater Treatment and Disposal Costs and Key Costing Assumptions
FMC Idaho, LLC.

Groundwater Treatment Alternative	Treatment Costs		Extraction, Conveyance, Monitoring and Disposal Costs		Total Capital Costs	Total Annual O&M	NPV O&M Costs (30 year, 7%discount rate)	NPV of reoccuring capital costs	Total PW Costs (Total Capital+ NPV of O&M + NPV of Reoccuring Capital Costs)	Cost Estimate Reference
	Capital Cost (2009 dollars)	Annual O&M Costs (2009 dollars)	Capital Cost (2009 dollars)	Annual O&M Costs Including Annual POTW Disposal Costs (2009 dollars)						
1 - Source and Institutional Controls with MNA			$57,000	$71,000	$57,000	$71,000	$881,042	$22,106	**$960,148**	Table 1
2A - Boundary Extract and Direct POTW Discharge	$0	$0	$579,000	$712,000	$579,000	$712,000	$8,835,237	$209,856	**$9,624,094**	Tables 2, 3, and 4
2B - Boundary Extraction and Treatment for Onsite Infiltration Basin	$1,474,000	$361,000	$1,261,000	$191,000	$2,735,000	$552,000	$6,849,791	$1,587,261	**$11,172,052**	Tables 5 , 7, and 8
3A - Source Area Extraction and Pretreatment Prior to POTW Discharge	$3,555,000	$479,000	$1,500,000	$872,000	$5,055,000	$1,351,000	$16,764,615	$3,269,530	**$25,089,145**	Tables 9, 10, 1, and 12
3B - Source Area Extraction and Treatment Prior to Discharge to Onsite Infiltration Basin	$4,432,000	$774,000	$2,051,000	$319,000	$6,483,000	$1,093,000	$13,563,082	$4,141,694	**$24,187,776**	Tables 13, 14, 15, and 16

Summary of Groundwater Treatment and Disposal Costs and Key Costing Assumptions
FMC Idaho, LLC.

Groundwater Treatment Alternative	Key Costing Assumtptions
1	1) Capital cost are for an estimated 10 additional (new) monitoring wells. 2) O&M costs are for the monitoring network / analytical parameters for the exisiting (2Q09) CERCLA programs plus 10 additional wells. 3) Samples will be collected semi-annual and reported on annually. 4) All costs are in 2009 dollars and all initial capital costs are incurred in 2009. 5) NPV of reoccuring capital costs includes capital costs for replacement of monitoring system components every 15-20 years over a 30 year period. The discount rate is 7%. 6) NPV for O&M costs assumes 30 year time period and 7% discount rate for O&M costs.
2A	1)Boundary extraction system consisting of five wells at 530 gpm will sufficiently capture the groundwater plume and COCs (Table 4.3). Capital cost includes installation and development of the extraction wells and installation of 3 (1-inch diameter) piezometers associated with each extraction well. O&M cost includes factored cost of 5% of total capital cost for equipment repair and maintainance. 2)POTW has sufficient capacity and will accept the 530 gpm flow rate at the COC concentrations without pretreatment. 3) POTW disposal cost of $2 per 1000 gallons. 4) Current sewer pipeline to POTW has sufficent capacity and integrity to convey pumping rate to POTW without improvements. This could be a significant cost if the piping has insufficient capacity or the piping is deteriorated. 5) Based on preliminary modeling results, assumes the flow rate or number of wells will not significantly change. 6) Groundwater monitoring (alternative 1 assumptions) is included in the capital and O&M cost. 7) All costs are in 2009 dollars and all initial capital costs are incurred in 2009. 8) NPV of reoccuring capital costs includes capital costs for replacement of extraction, conveyance, monitoring and disposal system components every 15-20 years over a 30 year period. The discount rate is 7%. 9) NPV for O&M costs assumes 30 year time period and 7% discount rate for O&M costs.
2B	1)Boundary extraction system consisting of five wells at 530 gpm will sufficiently capture the groundwater plume and COCs (Table 4.3). Capital cost includes installation and development of the extraction wells and installation of 3 (1-inch diameter) piezometers associated with each extraction well. O&M cost includes factored cost of 5% of total capital cost for equipment repair and maintainance. 2)With the exception of arsenic (MCL of 10 ppb), all other groundwater COCs will meet the MCLs without treatment prior to discharge to the infiltration basin. 3) Treatment for total phosphorus down to background levels (0.3 ppm of total P) will be required prior to discharge to infiltration basin. 4)The western borrow area will be used for the Infiltration basin and will have sufficient capacity to accept 530 gpm flow rate without modification. 5) The filter cake will require disposal at a hazardous waste landfill. 6) Based on preliminary modeling results, the flow rate or number of wells will not significantly change. 7) Treatment system will be placed in the area of the silica stockpile. 9) Groundwater monitoring (alternative 1 assumptions) is included in the capital and O&M cost. 10) All costs are in 2009 dollars and all initial capital costs are incurred in 2009. 11) NPV of reoccuring capital costs includes capital costs for replacement of extraction, conveyance, monitoring and disposal system components every 15-20 years over a 30 year period. The discount rate is 7%. 12) NPV for O&M costs assumes 30 year time period and 7% discount rate for O&M costs.
3A	1)Extraction system from three areas (fenceline boundary and 2 distinct source areas) consisting of 14 wells at a total flow rate of 670 gpm will sufficiently capture the source area plumes and associated COCs (Table 4.3). Capital cost includes installation and development of the extraction wells and installation of 3 (1-inch diameter) piezometers associated with each extraction well. O&M cost includes factored cost of 5% of total capital cost for equipment repair and maintainance. 2)POTW has sufficient capacity and will accept the 670 gpm flow rate. 3)With the exception of arsenic and total phosphorus, all other groundwater COCs will meet the POTW influent standards without treatment prior to discharge to the POTW. Pretreatment for arsenic and total phosphorus will be required to meet POTW influent standards. 4) The filter cake is nonhazardous. 5) Based on preliminary modeling results, the flow rate or number of wells will not significantly change. 6) POTW disposal cost of $2 per 1000 gallons. 7) Current sewer pipeline to POTW has sufficent capacity and integrity to convey pumping rate to POTW without improvements. This could be a significant cost if the piping has insufficient capacity or the piping is deteriorated. 8) The flow rate and number of wells will not significantly change based on future modeling. 9) Groundwater monitoring (alternative 1 assumptions) is included in the capital and O&M cost. 10) Pre treatment system will be placed in the area of the silica stockpile. 11) All costs are in 2009 dollars and all capital costs are incurred in 2009. 12) NPV of reoccuring capital costs includes capital costs for replacement of extraction, conveyance, monitoring and disposal system components every 15-20 years over a 30 year period. The discount rate is 7%. 13) NPV for O&M costs assumes 30 year time period and 7% discount rate for O&M costs.
3B	1)Extraction system from three areas (fenceline boundary and 2 distinct source areas) consisting of 14 wells at a total flow rate of 670 gpm will sufficiently capture the source area plumes and associated COCs (Table 4.3). Capital cost includes installation and development of the extraction wells and installation of 3 (1-inch diameter) piezometers associated with each extraction well. O&M cost includes factored cost of 5% of total capital cost for equipment repair and maintainance. 2)With the exception of arsenic, all other groundwater COCs will meet the MCLs without treatment prior to discharge to the infiltration basin. 3) Treatment for total phosphorus down to background levels (0.3 ppm of total P) and arsenic down to the MCL (10 ppb)will be required prior to discharge to infiltration basin. 4)The western borrow area will be used for the Infiltration basin and will have sufficient capacity to accept 670 gpm flow rate without modification. 5) The filter cake will be nonhazardous. 6) The flow rate and number of wells will not significantly change based on future modeling. 7) Treatment system will be placed in the area of the silica stockpile. 8) Groundwater monitoring (alternative 1 assumptions) is included in the capital and O&M cost. 9) All costs are in 2009 dollars and all capital costs are incurred in 2009. 10) NPV of reoccuring capital costs includes capital costs for replacement of extraction, conveyance, monitoring and disposal system components every 15-20 years over a 30 year period. The discount rate is 7%. 11) NPV for O&M costs assumes 30 year time period and 7% discount rate for O&M costs.

Table 1
Cost Estimate for Groundwater Monitoring
Groundwater Alternative 1
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs					
	Monitoring Well and Development	4" 160' deep with 10' Screen (PVC Sch 40)	10	$3,132.00	$31,320
				Direct Capital Cost Subtotal	**$31,320**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$10,962
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$4,698
	Contractor Overhead & Profit (15% of direct capital costs)				$4,698
	Design Costs (10% of direct capital and installation and contracting costs)				$5,168
				Indirect Capital Costs Subtotal	**$25,526**
				TOTAL CAPITAL COSTS	**$56,846**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Existing monitoring cost	Semi Annual sample for existing CERCLA wells	1	$43,000	$43,000
	Proposed	Semi annual sample for 10 new monitoring wells	1	$26,000	$26,000
	Equipment Allowance per year		1	$1,566	$1,566
				Total Annual O&M Cost	**$70,566**

Table 2
Groundwater Conveyance Cost Estimate
Groundwater Alternative 2A
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Well Water Pump Station Installation	6" 80 ft deep well with 10 ft screen	5	$30,000	$150,000
		Flow Meters for Wells	5	$1,500	$7,500
		Extraction Pumps (7.5 hp 80 to 130 gpm)	5	$6,000	$30,000
	Piping	8" HDPE Piping (530 gpm) from extration area to POTW line (ft)	2,600	$21.50	$55,900
	Trenching	Excavation (cy)	770	$6.35	$4,892
		Backfill (cy)	770	$5.70	$4,391
	Installation	Installation of Pipe	2,600	$3.00	$7,800
				Direct Capital Cost Subtotal	**$260,483**
Indirect Capital Costs					
	Installation and Contracting				
	Equipment Installation (15% of direct capital costs)				$39,072
	Mechanical Costs (10% of direct capital costs)	Valves & Appurtenances			$26,048
	Electrical and Instrumentation Costs (15% of direct capital costs)				$39,072
	Contractor Overhead & Profit (15% of direct capital costs)				$39,072
	Design Costs (10% of capital and installation and contracting costs)				$40,375
				Indirect Capital Costs Subtotal	**$183,640**
				TOTAL CAPITAL COSTS	**$444,123**

Cost Component	System Component	Item Description			Annual Cost
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	2		$36,500
	Electric 24h/dy all yr, $0.12/kWhr	Charge Pumps (5 x 7.5 Hp)	3		$29,368
	Equipment Allowance per year		1	$10,000	$10,000
	Sewer Fee	$2/1000 gallons	279093	$2	$558,186
				TOTAL ANNUAL O&M COST	**$634,054**

Table 3
Groundwater Monitoring Cost Estimate
Groundwater Alternative 2A
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Monitoring Well	4" 160 deep with 10' Screen (PVC Sch 40)	10	$3,132.00	$31,320
				Direct Capital Costs Subtotal	$31,320
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$10,962
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$4,698
	Contractor Overhead & Profit (15% of direct capital costs)				$4,698
	Design Costs (10% of capital and installation and contracting costs)				$5,168
				Indirect Capital Cost Subtotal	**$25,526**
				TOTAL CAPITAL COST	**$56,846**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Existing monitoring cost	Semi annual sample for existing CERCLA wells	1	$43,000	$43,000
	Proposed	Semi annual sample for 10 new monitoring wells	1	$26,000	$26,000
	Equipment Allowance per year		1	$1,566	$1,566
				TOTAL ANNUAL O&MCOST	**$70,566**

Table 4
Piezometer Cost Estimate
Groundwater Alternative 2A
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Piezometer Well	1" 80' deep with 30' Screen (PVC Sch 40)	15	$2,834.00	$42,510
				Direct Capital Cost Subtotal	$42,510
Indirect Capital Costs	**Installation Costs**				
	Equipment Installation (35% of direct capital costs)				$14,879
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$6,377
	Contractor Overhead & Profit (15% of direct capital costs)				$6,377
	Design Costs (10% of equipment capital costs and installation costs)				$7,014
				Indirect Capital Cost Subtotal	**$34,646**
				TOTAL CAPITAL COST	**$77,156**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost	Monitoring once a month, 8 hr/m	Labor salary - $50 / hour	8		$4,800
	Equipment Allowance per year		1	$2,126	$2,126
				TOTAL ANNUAL O&M COST	**$6,926**

Table 5
Groundwater Treatment Cost Estimate
Groundwater Alternative 2B
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Chemcial Addition System	Mixing Tank and Mixer	1	$80,000	$80,000
		Coagulant Tank	1	$5,000	$5,000
		Coagulant and Polymer Feed Pump	3	$2,500	$7,500
		Polyblend Unit	1	$20,000	$20,000
	Direct Filtration	Parkson Dynasand (DSF 64 DBTF)	2	$90,000	$180,000
		Ingersol 5 hp Compressor with Desicant Dryer	1	$29,000	$29,000
		20,000 gallon Filtered Water Storage Tank	1	$15,000	$15,000
		550 gpm Transfer Pump	2	$25,000	$50,000
	Backwash Treatment	Backwashwaste Tank, 4000 gallons	1	$4,000	$4,000
		Backwash Transfer Pump	2	$2,000	$4,000
		Small Mxing Tank and Mixer	1	$25,000	$25,000
		Polymer Feed Pumps	3	$1,500	$4,500
		LGS 200/55 Lamella Settler	1	$66,000	$66,000
		Sludge Thickener	1	$10,000	$10,000
		Filter Press	1	$50,000	$50,000
		ABEL Diaphragm Pump	2	$8,000	$16,000
				Direct Capital Cost Subtotal	**$566,000**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (30% of direct capital costs)				$169,800
	Mechanical Costs (30% of direct capital costs)				$169,800
	Electrical and Instrumentation Costs (25% of direct capital costs)				$141,500
	Contractor Overhead & Profit (15% of direct capital costs)				$84,900
	WTP Civil Works	Yard Piping	LS	$20,000	$20,000
		Foundation (cy concrete)	52	$400	$20,800
	Equipment Buildings	20 ft x 30 ft Treatment Building ($75/sqft)	600	$75	$45,000
	Design Costs (10% of Installed equipment and civil costs)				$121,780
	Contingency (10% of direct and indirect capital costs)				$133,958
				Indirect Capital Cost Subtotal	**$907,538**
				TOTAL CAPITAL COSTS	**$1,473,538**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	10		$182,500
	Electric 24h/dy all yr, $0.12/kWhr	Large Mixers (2 x 5 hp)	2		$7,831
		Chemical Feed Pumps (2 x 1 hp)	2		$1,566
		Compressor (1 x 5 hp)	1		$3,916
		Transfer Pump (1 x 25 hp)	1		$19,579
		Backwash Waster Transfer Pump (1 x 1 hp)	1		$783
		Small Mixer (2 x 1 hp)	2		$1,566
		Polymer Feed Pumps (2 x 0.5 hp)	2		$783
		Lamella Settler (2 x 0.5 hp)	2		$783
		Filter Press (1 x 5 Hp)	1		$979
		Diaphragm Pump (1 x 2 hp)	1		$3,133
	Chemical Costs	Coagulant (conservative cost) at $0.28/lb			$32,526
		polymer			$10,000
		Sludge Disposal at $200/ton	232	$200	$46,465
	Heat for tanks & building				$10,000
	Analytical Allowance				$10,000
	Equipment Allowance per year (5%)				$28,300
				TOTAL ANNUAL O&M COST	**$360,710**

Table 6
On-Site Disposal Cost Estimate
Groundwater Alternative 2B
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Well Water Pump Station Installation	6" 80 ft deep well (80 to 130 gom)	5	$30,000	$150,000
		Flow Meters for Wells	5	$1,500	$7,500
		Extraction Pumps (7.5 hp 80 to 130 gpm)	5	$6,000	$30,000
	Piping	8" HDPE Piping (530 gpm) from extraction point to treatment system (ft)	2,400	$21.50	$51,600
		8" HDPE Piping (530 gpm) from treatment system t POTW line (ft)	10,200	$21.50	$219,300
	Trenching	Excavation (cy)	3,733	$6.35	$23,707
		Backfill (cy)	3,733	$5.70	$21,280
	Installation	Installation of Pipe	12,600	$3.00	$37,800
	Evaporation and Filtration System	Distributors		$100,000.00	$100,000
				Direct Capital Costs Subtotal	**$641,187**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (15% of direct capital costs)				$96,178
	Mechanical Costs (10% of direct capital costs)	Valves & Appurtenances			$64,119
	Electrical and Instrumentation Costs (15% of direct capital costs)				$96,178
	Contractor Overhead & Profit (15% of direct capital costs)				$96,178
	Design Costs (10% of direct and installation and contracting)				$99,384
				Indirect Capital Costs Subtotal	**$452,037**
				TOTAL CAPITAL COSTS	**$1,093,223**

Cost Component	System Component	Item Description			Annual Cost
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	4		$73,000
	Electric 24h/dy all yr, $0.12/kWhr	Charge Pumps (5 x 7.5 Hp)	5		$29,368
	Equipment Allowance per year		1	$10,000	$10,000
				TOTAL ANNUAL O&M COST	**$112,368**

Table7
Groundwater Monitoring Cost Estimate
Groundwater Alternative 2B
FMC idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Monitoring Well	4"160' deep with 10' Screen (PVC Sch 40)	10	$3,132.00	$31,320
				Direct Capital Cost Subtotal	**$31,320**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$10,962
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$4,698
	Contractor Overhead & Profit (15% of direct capital costs)				$4,698
	Design Costs (10% of direct and installation and contracting costs)				$5,168
				Indirect Capital Costs Subtotal	**$56,846**
				TOTAL DIRECT CAPITAL COSTS	**$88,166**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Existing monitoring cost	Semi annual sample for existing CERCLA wells	1	$43,000	$43,000
	Proposed	Semi annual sample for 10 new monitoring wells	1	$26,000	$26,000
	Equipment Allowance per year		1	$1,566	$1,566
				TOTAL ANNUAL O&M COST	**$70,566**

Table 8
Piezometer Cost Estimate
Groundwater Alternative 2B
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Piezometer Well	1" 80' deep with 30' Screen (PVC Sch 40)	15	$2,834.00	$42,510
				Direct Capital Cost Subtotal	**$42,510**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$14,879
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$6,377
	Contractor Overhead & Profit (15% of direct capital costs)				$6,377
	Design Costs (10% of direct capital and installation and contracting costs)				$7,014
				Indirect Capital Costs Subtotal	**$34,646**
				TOTAL CAPITAL COSTS	**$77,156**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Monitoring once a month, 8 hr/m	Labor salary - $50 / hour	8		$4,800
	Equipment Allowance per year		1	$2,126	$2,126
				TOTAL ANNUAL O&M COST	**$6,926**

Table 9
Groundwater Treatment Cost Estimate
Groundwater Alternative 3A
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs					
	Equalization	162,000 gallon EQ tank with Insulation (4 hrs)	1	$220,000	$220,000
		700 gpm Feed Pump	2	$25,000	$50,000
	Lime Feed System	Lime Silo	1	$75,000	$75,000
		Lime Feed System and Mixing Tank	1	$100,000	$100,000
		Lime Fedd Pump	2	$2,500	$5,000
	Clarifier	Polymer Feed Pump	2	$2,500	$5,000
		Polyblend Unit	1	$20,000	$20,000
		Rapid Mix/Floc/Settler/Thickener	1	$720,000	$720,000
		30,000 gallon Storage Tank	1	$90,000	$90,000
	pH ajustment	CO2 Feed System & 50 Ton Tank	1	$174,000	$174,000
		pH Adjustment Tank (14,000 gallons) with mixer	1	$62,000	$62,000
	Solids Handling	Polymer Feed Pump	2	$2,500	$5,000
		Filter Press	1	$250,000	$250,000
		ABEL Diaphragm Pump	2	$13,000	$26,000
		700 gpm Transfer Pump	2	$25,000	$50,000
			Direct Capital Costs Subtotal		**$1,402,000**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (30%)				$420,600
	Mechanical Costs (30%)				$420,600
	Electrical and Instrumentation Costs (25%)				$350,500
	Contractor Overhead & Profit (15%)				$210,300
	WTP Civil Works	Yard Piping	LS	$25,000	$25,000
		Foundation (cy concrete)	160	$400	$64,000
	Equipment Buildings	30 ft x 20 ft Treatment Building ($75/sqft)	600	$75	$45,000
	Design Costs (10% of Installed equipment and capital costs)				$293,800
	Contingency (10% of direct and indirect capital costs)				$323,180
			Indirect Capital Cost Subtotal		**$2,152,980**
			TOTAL CAPITAL COST		**$3,554,980**

Cost Component	System Component	Item Description			Annual Cost
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	8		$146,000
	Electric 24h/dy all yr, $0.12/kWhr	Feed Pump (1 x 15 hp)	1		$11,747
		Lime Feed System and Mixing Tank (1 x 5 hp)	1		$3,916
		Chemical Feed Pumps	3		$705
		Rapid Mix/Floc/Settler/Thickener (1 x 15)	1		$88,104
		CO2 Feed System (1 x 2 hp)	1		$1,566
		pH Adjustment Tank mixer (1 x 5 hp)	1		$3,916
		Filter Press (1 x 20 Hp)	1		$3,133
		Diaphragm Pump (1 x 7.5 hp)	1		$3,133
		Transfer Pump (1x 25 hp)	1		$19,579
	Chemical Costs	Lime (200 ppm dosage) at $75/ton	296	$75	$22,191
		Carbon Dioxide			$10,000
		polymer			$15,000
		Sludge Disposal at $85/ton	598	$100	$59,775
	Heat for tanks & building				$10,000
	Analytical Allowance				$10,000
	Equipment Allowance per year (5%)				$70,100
			TOTAL ANNUAL O&M COST		**$478,864**

Table 10
Groundwater Conveyance Cost Estimate
Groundwater Alternative 3A
FMC Idaho, LLC

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Well Water Pump Station Installation	6" 80 ft deep (13-19 gpm) well (Source A)	4	$30,000	$120,000
		6" 80 ft deep (17-20 gpm) well (Source B)	5	$30,000	$150,000
		6" 80 ft deep (80 to 130 gom) well (Alt. 2 area)	5	$30,000	$150,000
		Flow Meters for Wells	14	$1,500	$21,000
		Extraction Pumps (1 hp 13 to 20 gpm)	9	$2,500	$22,500
		Extraction Pumps (7.5 hp 80 to 130 gpm)	5	$6,000	$30,000
	Piping	4" HDPE Piping (80 gpm) from Source A to Source B (ft)	1,600	$10.40	$16,640
		4" HDPE Piping (305gpm) from Source B to treatment plant (ft)	3,400	$10.40	$35,360
		8" HDPE Piping (520 gpm) from extration area (Alter 2 area) to treatment plant (ft)	2,400	$21.50	$51,600
		8" HDPE Piping (672 gpm) from treatment facility to POTW line (ft)	2,000	$21.50	$43,000
	Trenching	Excavation (cy)	4,178	$6.35	$26,529
		Backfill (cy)	4,178	$5.70	$23,813
	Installation	Installation of Pipe	9,400	$3.00	$28,200
				Direct Capital Cost Subtotal	**$718,642**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (15% of direct capital costs))				$107,796
	Mechanical Costs (10% of direct capital costs)	Valves & Appurtenances			$71,864
	Electrical and Instrumentation Costs (15% of direct capital costs)				$107,796
	Contractor Overhead & Profit (15% of direct capital costs)				$107,796
	Design Costs (10% off direct and installation and contracting costs)				$111,390
				Indirect Capital Cost Subtotal	**$506,643**
				TOTAL CAPITAL COSTS	**$1,225,285**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	2		$36,500
	Electric 24h/dy all yr, $0.12/kWhr	Charge Pumps (9 x 1 Hp)	9		$7,048
		Charge Pumps (5 x 7.5 Hp)	5		$29,368
	Annual Sewer Fee	$2/1000 gallon	353203	2	$706,406
	Equipment Allowance per year		1	$10,000	$10,000
				TOTAL ANNUAL O&M COST	**$789,322**

Table 11
Groundwater Monitoring Costs
Groundwater Alternative 3A
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Monitoring Well	4" 160' deep with 10' Screen (PVC Sch 40)	10	$3,132.00	$31,320
				Direct Capital Cost Subtotal	**$31,320**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$10,962
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$4,698
	Contractor Overhead & Profit (15% of direct capital costs)				$4,698
	Design Costs (10% of direct and installation and contracting costs)				$5,168
				Indirect Capital Costs Subtotal	**$25,526**
				TOTAL CAPITAL COSTS	**$56,846**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Existing monitoring cost	Semi annual sample for existing CERCLA wells	1	$43,000	$43,000
	Proposed	Semi annual sample for 10 new monitoring wells	1	$26,000	$26,000
	Equipment Allowance per year		1	$1,566	$1,566
				TOTAL ANNUAL O&M COST	**$70,566**

Table 12
Piezometer Cost Estimate
Groundwater Alternative 3A
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Piezometer Well	1" 80' deep with 30' Screen (PVC Sch 40)	42	$2,834.00	$119,028
				Direct Capital Cost Subtotal	**$119,028**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$41,660
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$17,854
	Contractor Overhead & Profit (15% of direct capital costs)				$17,854
	Design Costs (10% of direct and installation and contracting costs)				$19,640
				Indirect Capital Cost Subtotal	**$97,008**
				TOTAL CAPITAL COST	**$216,036**

Cost Component	System Component	Item Description			Annual Cost
Operation and Maintenance Cost					
	Monitoring once a month, 8 hr/m	Labor salary - $50 / hour	8		$4,800
	Equipment Allowance per year		1	$5,951	$5,951
				TOTAL ANNUAL O&M COST	**$10,751**

Table 13
Groundwater Treatment Cost Estimate
Groundwater Alternative 3B
FMC idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
DirectCapital Costs					
	Equalization	162,000 gallon EQ tank with Insulation (4 hrs)	1	$220,000	$220,000
		700 gpm transfer Pump	2	$25,000	$50,000
	Lime Feed System	Lime Silo	1	$75,000	$75,000
		Lime Feed System and Mixing Tank	1	$100,000	$100,000
		Lime Fedd Pump	2	$2,500	$5,000
	Clarifier	Polymer Feed Pump	2	$2,500	$5,000
		Polyblend Unit	1	$20,000	$20,000
		Rapid Mix/Floc/Settler/Thickener	1	$720,000	$720,000
	Filtration	Multimedia Filter Pumps	2	$25,000	$50,000
		Skid Mounted 3 x 120" Dia Multimedia Filter	1	$220,000	$220,000
		Backwash Pumps	2	$25,000	$50,000
		30,000 gallon Filtered Water Storage Tank	1	$90,000	$90,000
	pH ajustment	CO2 Feed System & 50 Ton Tank	1	$174,000	$174,000
		pH Adjustment Tank (14,000 gallons) with mixer	1	$62,000	$62,000
	Solids Handling	Polymer Feed Pump	2	$2,500	$5,000
		Filter Press	1	$250,000	$250,000
		ABEL Diaphragm Pump	2	$13,000	$26,000
		700 gpm Transfer Pump	2	$35,000	$70,000
			Direct Capital Cost Subtotal		**$1,742,000**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (30% of direct capital costs)				$522,600
	Mechanical Costs (30% of direct capital costs)				$522,600
	Electrical and Instrumentation Costs (25% of direct capital costs)				$435,500
	Contractor Overhead & Profit (15% of direct capital costs)				$261,300
	WTP Civil Works	Yard Piping	LS	$25,000	$25,000
		Foundation (cy concrete)	160	$400	$64,000
	Equipment Buildings	30 ft x 40 ft Treatment Building ($75/sqft)	1200	$75	$90,000
	Design Costs (10% of Installed equipment and civil costs)				$366,300
	Contingency (10% of all costs)				$402,930
			Indirect Capital Cost Subtotal		**$2,690,230**
			TOTAL CAPITAL COST		**$4,432,230**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	12		$219,000
	Electric 24h/dy all yr, $0.12/kWhr	Feed Pump (1 x 15 hp)	1		$11,747
		Lime Feed System and Mixing Tank (1 x 5 hp)	1		$3,916
		Chemical Feed Pumps	3		$705
		Rapid Mix/Floc/Settler/Thickener (1 x 15)	1		$88,104
		Filter Pump (1x 15 hp)	1		$11,747
		Backwash Pump (1 x 15 hp)	1		$1,175
		CO2 Feed System (1 x 2 hp)	1		$1,566
		pH Adjustment Tank mixer (1 x 5 hp)	1		$3,916
		Filter Press (1 x 20 Hp)	1		$3,133
		Diaphragm Pump (1 x 7.5 hp)	1		$3,133
		Transfer Pump (1x 30 hp)	1		$23,494
	Chemical Costs	Lime (500 ppm dosage) at $150/ton	740	$150	$110,957
		Carbon Dioxide			$10,000
		polymer			$15,000
		Sludge Disposal at $85/ton	1,494	$100	$149,438
	Heat for tanks & building				$20,000
	Analytical Allowance				$10,000
	Equipment Allowance per year (5%)				$87,100
			TOTAL ANNUAL O&M COST		**$774,130**

Table 14
Groundwater Conveyance Cost Estimate
Groundwater Alternative 3B
FMC idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Well Water Pump Station Installation	6" 80 ft deep (13-19 gpm) well (Source A)	4	$30,000	$120,000
		6" 80 ft deep (17-20 gpm) well (Source B)	5	$30,000	$150,000
		6" 80 ft deep (80 to 130 gom) well (Alt. 2 area)	5	$30,000	$150,000
		Flow Meters for Wells	14	$1,500	$21,000
		Extraction Pumps (1 hp 13 to 20 gpm)	9	$2,500	$22,500
		Extraction Pumps (7.5 hp 80 to 130 gpm)	5	$6,000	$30,000
	Piping	4" HDPE Piping (80 gpm) from Source A to Source B (ft)	1,600	$10.40	$16,640
		4" HDPE Piping (305gpm) from Source B to treatment plant (ft)	3,400	$10.40	$35,360
		8" HDPE Piping (520 gpm) from extration area (Alter 2 area) to treatment plant (ft)	2,400	$21.50	
		8" HDPE Piping (675 gpm) from treatment facility to infiltration basin (ft)	11,200	$21.50	$240,800
	Trenching	Excavation (cy)	8,267	$6.35	$52,493
		Backfill (cy)	8,267	$5.70	$47,120
	Installation	Installation of Pipe	18,600	$3.00	$55,800
	Evaporation and Filtration System	Distributors		$100,000.00	$100,000
				Direct Capital Cost Subtotal	**$1,041,713**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (15% of direct costs)				$156,257
	Mechanical Costs (10% of direct capital costs)	Valves & Appurtenances			$104,171
	Electrical and Instrumentation Costs (15% of direct capital costs)				$156,257
	Contractor Overhead & Profit (15% of direct capital costs)				$156,257
	Design Costs (10% of direct and installation and contracting costs)				$161,466
				Indirect Capital Cost Subtotal	**$734,408**
				TOTAL CAPITAL COST	**$1,776,121**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Hours per day calculated	Labor salary - $50 / hour	4		$73,000
	Electric 24h/dy all yr, $0.12/kWhr	Charge Pumps (9 x 1 Hp)	9		$7,048
		Charge Pumps (5 x 7.5 Hp)	5		$146,840
	Equipment Allowance per year		1	$10,000	$10,000
				TOTAL ANNUAL O&M COST	**$236,888**

Table 15
Groundwater Monitoring Cost Estimate
Groundwater Alternative 3B
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Monitoring Well	4" 160' deep with 10' Screen (PVC Sch 40)	10	$3,132.00	$31,320
				Direct Capital Cost subtotal	**$31,320**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$10,962
	Mechanical Costs (15% of direct capital costs)	Valves & Appurtenances			$4,698
	Contractor Overhead & Profit (15% of direct capital costs)				$4,698
	Design Costs (10% of direct and installation and contracting costs)				$5,168
				Indirect Capital cost Subtotal	**$25,526**
				TOTAL CAPITAL COST	**$56,846**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost					
	Existing monitoring cost	Semi annual sample for existing CERCLA wells	1	$43,000	$43,000
	Proposed	Semi annual sample for 10 new monitoring wells	1	$26,000	$26,000
	Equipment Allowance per year		1	$1,566	$1,566
				TOTAL ANNUAL O&M COST	**$70,566**

Table 16
Piezometer Cost Estimate
Groundwater Alteernative 3B
FMC Idaho, LLC.

Cost Component	System Component	Item Description	Quantity	UNIT COST	Total Cost
Direct Capital Costs	Piezometer Well	1" 80' deep with 30' Screen (PVC Sch 40)	42	$2,834.00	$119,028
				Direct Capital Cost Subtotal	**$119,028**
Indirect Capital Costs	**Installation and Contracting**				
	Equipment Installation (35% of direct capital costs)				$41,660
	Mechanical Costs (15% od direct capital costs)	Valves & Appurtenances			$17,854
	Contractor Overhead & Profit (15% of direct capital costs)				$17,854
	Design Costs (10% of direct and installation and contracting costs)				$19,640
				Indirect Capital Cost Subtotal	**$97,008**
				TOTAL CAPITAL COST	**$216,036**
Cost Component	**System Component**	**Item Description**			**Annual Cost**
Operation and Maintenance Cost	Monitoring once a month, 8 hr/m	Labor salary - $50 / hour	8		$4,800
	Equipment Allowance per year		1	$5,951	$5,951
				TOTAL ANNUAL O&M COST	**$10,751**

Rob Hartman

From: Rob Hartman
Sent: Friday, June 11, 2010 1:57 PM
To: Kira Lynch
Cc: Sue Skinner; marianne.e.walsh@erdc.usace.army.mil; Rock.Steven@epamail.epa.gov; Reisman.David@epamail.epa.gov; Doug Tanner; Scott.Miller@deq.idaho.gov; Kelly Wright; Susan Hansen; Barbara Ritchie; Marc Bowman; Leah Wolf-Martin; Nick Gudka; David M Heineck; John.Stillmun@fmc.com
Subject: FMC Response to Comments – Draft Supplemental Feasibility Study Report (March 2010)
Attachments: 2010-06-11 FMC Response to Agency Comments on Draft SFS Report.pdf

Attached please find FMC's Response to Comments on the Draft Supplemental Feasibility Study Report. Thank you, Rob.

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Via Email

June 11, 2010

Ms. Kira Lynch, MS ECL-113
US Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Re: Administrative Order on Consent (AOC) for Supplemental Remedial Investigation/Feasibility Study for the FMC Plant Operable Unit (U.S. EPA Docket No. CERCLA 10-2004-0010):
Response to Comments –
Draft Supplemental Feasibility Study Report (March 2010)

Dear Ms. Lynch:

FMC is submitting the attached response to nine (9) sets of comments received by FMC from various reviewers of the draft Supplemental Feasibility Study Report (draft SFS) which FMC submitted pursuant to the above referenced order on March 4, 2010. FMC had received preliminary comments from some reviewers that were discussed in a meeting on March 30-31, 2010 in Pocatello. Following discussions at those meetings, additional comments were received in April and May 2010, and the attached response addresses all of the final comments (or preliminary comments if not superseded by final comments). The attached response to comments includes a table of the comment documents and then the comments are presented verbatim from the source document followed by FMC's responses for each enumerated general, specific or narrative comment.

Please advise of any remaining issues with FMC's responses. FMC would anticipate being able to make all the revisions suggested in our attached responses and prepare the final report in hard copy form approximately two weeks after your substantive concurrence with the suggested revisions described in the attachments. Please call me with any questions, or to discuss further.

Sincerely,

Barbara E. Ritchie
Associate Director, Environment
FMC Corporation

cc: Doug Tanner
Waste and Remediation Manager
State of Idaho Department of Environmental Quality
444 Hospital Way #300
Pocatello, ID 83201

RCRA/CERCLA Program Manager
Shoshone-Bannock Tribes
P.O. Box 306 – Pima Drive
Fort Hall, ID 83203

FMC Responses to EPA, IDEQ and Shoshone Bannock Tribes Comments on the Draft SFS Report for the FMC Plant OU, March 2010

FMC's responses are provided immediately following the general, specific and narrative comments contained in the following list of EPA, IDEQ and Shoshone Bannock Tribes documents.

Comment Title/Date/Reviewer	Referenced as:	Beginning on page number
EPA Comments on the March 2010 Supplemental Feasibility Study (SFS) May 26, 2009 **EPA, Kira Lynch**	(EPA, K. Lynch)	1
Draft Comments on the Draft Supplemental Feasibility Study Report for the FMC Plant Operable Unit – March 2010 **USACE, Marianne E. Walsh**	(USACE, M.E. Walsh)	12
Comments of FMC/MWH March 2010 DRAFT Supplemental Feasibility Study (SFS) **EPA ORD, David J. Reisman,**	(EPA, D.J. Reisman)	15
Review of Soil Alternatives for FMC in "Supplemental Remedial Investigation/Feasibility Study" with emphasis on ET cover applications **EPA, Steve Rock**	(EPA, S. Rock)	23
Comments on FMC/MWH draft Volume 1& 2 Supplemental Feasibility Study Report for the FMC Plant Operable Unit of the EMF Superfund Site, Pocatello, Idaho, March 2010. **EPA, Bernie Zavala**	(EPA, B. Zavala)	26
Review Comments for Groundwater Model Report **EPA, Randall R. Ross Applied Research & Technical Support Branch**	(EPA, R. Ross)	39

Comment Title/Date/Reviewer	Referenced as:	Beginning on page number
Review of Quality Assurance Project Plan for Interim CERCLA Groundwater Monitoring for the FMC Site, FMC Idaho, LLC, March, 2010 **Donald Matheny, Chemist Environmental Services Unit, Office of Environmental Assessment March 11, 2010**	(EPA, D. Matheny)	46
DEQ Comments on the March 2010 FMC OU Draft Supplemental Feasibility Study, April 23, 2010	(IDEQ Comments)	48
Shoshone Bannock Tribes SFS Comments and attachments May 10, 2010 ***Comments of the Shoshone-Bannock Tribes Supplemental Feasibility Study Report- March 2010 Eastern Michaud Flats, FMC Plant Operable Unit***	(ShoBan Comments)	55

EPA Comments on the March 2010 Supplemental Feasibility Study (SFS)
May 26, 2009

General Comments

1. EPA does not agree that Alternative 2 for the soils meets the threshold protectiveness requirement. In addition, the Overall protection of human health for Alternative 4 should be high.

   FMC Response: FMC continues to assert that Alternative 2 for soils meets the threshold protectiveness requirement for all areas of the FMC Plant OU, including soils and fill materials that have been identified for "receptor-initiated remediation," i.e., do not pose a threat to groundwater and do not contain elemental phosphorus. FMC believes that soils/fill that, under the conservative assumptions in the EPA Risk Assessment guidance documents, show a threat primarily due to gamma radiation exposure and only to hypothetical future workers under an industrial redevelopment scenario, do not require remedial action until such time as potential site workers would become a reality. At such time, e.g., site redevelopment, parking lots and building foundations could be incorporated such that these structures and facilities would serve to provide the same level of protectiveness as capping.

   In FMC's review of the soil alternatives, Alternative 4 was ranked "Moderate" for overall protection of human health and the environment (as compared to Alternative 3 which was ranked "high") due to the use of "excavation and consolidation" in RA-A, RA-A1, and RA-K. During implementation of the remedial action specified under Alternative 4, the excavation and movement of 1.2 million cubic yards of impacted fill material and over 4,200 cubic yards of P4-impacted soil would be required. Even using the state-of-the-art control measures, fugitive emissions impacts to ambient air would be expected. Further, risk of occupational injury during the use of heavy equipment to move this magnitude of soil is significantly increased compared to Alternative 3. Therefore, FMC believes that Alternative 4 is appropriately ranked lower than Alternative 3 due to potential impacts to human health and the environment during remedial action implementation.

2. ICs and MNA for groundwater without treatment will not meet ARARs within a reasonable timeframe. Groundwater Alternative 2 or 3 will be required as part of the selected alternative.

   FMC Response: The draft SFS Report clearly states that none of the groundwater alternatives (0, 1, 2 or 3) will meet the RAO for groundwater restoration or achieve the arsenic MCL (ARAR) in groundwater beneath the FMC Plant Site within a reasonable timeframe. EPA will document their preferred groundwater alternative in the Proposed Plan and, following the comment period, EPA will document its selected alternative in a ROD amendment for the FMC Plant OU. No revision to the SFS Report is necessary to address this comment.

3. In the discussion of groundwater in various places in the document (e.g., Section 2.4.9, second paragraph, page 2-26) the text makes the statement that COCs in groundwater do not migrate beyond the FMC and Simplot owned properties. This statement is inaccurate and misleading. With the exception of COCs that are sorbed onto the sediments, virtually all of the site-related COCs in groundwater migrate beyond the company owned properties and are discharged to surface water. The text should be revised to reflect this and references claiming that COCs do not migrate beyond the company owned boundaries should be removed.

   FMC Response: The summary of the GWCCR presented in Section 2.4.9, second paragraph was taken verbatim from the GWCCR – June 2009 Final. The second and third sentences were previously revised as requested by EPA based on its comments on the draft GWCCR, October 2008. The second sentence is accurate as written and conveys important information regarding the extent and transport of the EMF groundwater plume (i.e., no Off-Plant OU wells are site-impacted and potential new Off-Plant OU wells would not encounter EMF-contaminated groundwater). FMC does not believe the statement is misleading as it is immediately followed by the third sentence that accurately describes migration of EMF-impacted groundwater into the Off-Plant OU as <u>surface</u> water. FMC believes the same or similar text that distinguishes between these media (groundwater and surface water) is accurate throughout the SFS. No revision to the SFS Report is necessary to address this comment.

4. There are many references in the document that state that conventional excavation is typically considered for large areas with relatively shallow fill depths (typically 2 – 4 feet) because capping is more cost effective. This analysis should be provided somewhere in the document.

   FMC Response: A footnote will be added to the last sentence of the second paragraph of Section 5.2.4.1 (page 5-9) and to the second sentence of the paragraph labeled <u>Decision Rationale</u> in Section 6.2.4.1 (page 6-25) to read:

   This statement is based upon the cost estimates developed for construction of ET covers and for performing conventional excavation on a per acre basis. The cost to construct one acre of ET cap is estimated to be $85,000/acre. The cost for conventional excavation (no P4 present) of one acre to a depth of 1 foot of slag (e.g., at RA-A) is estimated to be $40,300. This cost includes ripping, excavation, and transport to another RA (e.g., RA-F) for placement prior to capping followed by replacement with clean fill material. Therefore, conventional excavation of 2.5 feet of slag will approximately equal the cost to cover the same area with an ET cover. This provides a "break-even" point of for capping versus excavation of "2 to 4 feet."

5. While Section 7.2 provides an informative history of the development of Table 7-2, this table does not relieve FMC of the responsibility of presenting information in the

SFS that supports the technology decisions presented in the assembled alternatives. These process options and alternatives may change based on information presented in the SFS and input from stakeholders and the public.

FMC Response: Acknowledged. No revision to the SFS Report is necessary to address this comment.

6. Alternative 3 should be revised to allow flexibility prior to the actual implementation of remedial alternatives in areas that do not contain P4. Targeted areas are those that have a selected remedy of a gamma cap. This would be in an attempt to maximize the potential for redevelopment and reuse of property or for use as a future infiltration pond in the event extracted groundwater is disposed of using this alternative. This flexibility would allow for the consolidation of fill materials and reuse of areas proposed for gamma caps in an effort to maximize land reuse and existing assets on the property. This flexibility would have a finite window of opportunity that could be exercised from the time of remedial alternative selection until the date that remedial action is set to commence. In order to provide the longest reasonable timeframe to implement the remedial action, RA's could be prioritized so that remedial action is implemented at the highest risk areas first (such as the furnace building) and the lower risk areas (i.e., gamma cap areas) could be remediated last.

   FMC Response: FMC acknowledges and agrees with EPA's identification of a need for flexibility during implementation of the selected remedial action to accommodate redevelopment at the site; however, FMC believes that SFS Soil Alternative 2 allows a greater opportunity to integrate redevelopment projects in the ultimate capping remedy for those areas of the site. For this reason, FMC selected Soil Alternative 2 as the preferred soil alternative, which provides the most flexibility.

   FMC agrees to revise Section 7.3.3 Soil Alternative 3 to state that areas identified for a gamma cap in RA-A and RA-G could be replaced with a stormwater retention basin, building foundation or parking lot(s) during the RD phase, based on final design and redevelopment plans which exist at that time, which would be design to be as (or more) protective than the gamma cap.

<u>Specific Comments</u>

1. **Table 4-2, Remedial Action Objectives.** Add the following RAO to this table, "Minimize generation and prevent exposure to phosphine and other gases." In addition change the P4 RAO to read, "prevent the direct exposure to elemental phosphorus under conditions that may spontaneously combust, posing a fire hazard **or** resultant air emissions that represent a significant risk to human health and the environment."

   FMC Response: Table 4-2 will be revised to include the new RAO for phosphine and other gases and to modify the P4 RAO to be consistent with EPA's suggested language. The conceptual site model presumes that phosphine (the primary gas of concern) is generated through a hydrolysis reaction of P4 and water. All of the soil

alternatives, with the exception of Alternative 1 – No Action and Alternative 6 – Excavation and Treatment of all P4, involve placement of ET caps over areas with P4 remaining in place. (Note that Soil Alternative 5 involves removal and treatment of P4 down to 10 feet and then capping remaining P4 and other COCs). A properly designed, installed, and maintained ET cap will prevent further infiltration of water from the surface to the P4 waste zone, thus minimizing future P4/water hydrolysis and generation of phosphine. Further, institutional controls and monitoring will prevent future direct exposure to phosphine and other gases. Alternatives 5 and 6, on the other hand, would involve excavation and exposure of P4 wastes along with the addition of significant quantities of water to control P4 oxidation during excavation. This would greatly increase the possibility of generation of and exposure to phoshpine and other gases of concern. Alternatives 5 and 6 are estimated to require 25 to 40 years, respectively, for the excavation/treatment process. The capping alternatives therefore provide the best opportunity for achievement of both of these RAOs.

2. **Section 5.2.5.3, Thermal Desorption.** The report eliminates thermal desorption from further consideration in the screening phase due to excavation, storage, and safety issues during treatment. However, it appears that these same issues would also be present during the implementation of incineration technology which was retained for further consideration. Either thermal desorption should be retained and carried into the final screening of technologies (and potentially the detailed analysis of alternatives) or the differences between the two technologies should be clarified to support the elimination of thermal desorption.

   FMC Response: EPA is correct in that all of the ex-situ treatment processes have similar problems associated with excavation, storage, and health/safety issues associated with P4 wastes prior to treatment. However, as explained in Section 5.2.5.3, ex-situ thermal desorption also would require a long time to treat higher concentrations of P4 (i.e., for individual batches) and would present a fire or explosive hazard during relatively low-temperature treatment (i.e., 200 to 600 degrees F). In addition, thermal desorption has not been demonstrated on similar P4-containing wastes, i.e., 10% P4 mixed with other site fill materials containing metals and radionuclides. When the technical implementability challenges presented by ex-situ thermal desorption are compared to the incineration process, a demonstrated technology on these types of wastes, incineration was deemed a significantly more viable treatment technology for wastes containing P4. In addition, there are off-site incinerators that are commercially available and are considered viable for treating small quantities of waste containing P4 greater than 1,000 ppm (e.g., underground piping). As a result, thermal desorption was screened out while on-site and off-site ex-situ incineration was retained.

   In Section 5, many other ex-situ treatment technologies for P4 wastes were screened and judged viable for further detailed screening in Section 6. These technologies (in addition to ex-situ incineration) included stabilization/solidification, chemical oxidation, and chemical hydrolysis. It should be noted that the objective for the technical implementability screening process presented in Section 5 is not only to

eliminate those processes that are not technically implementable, but also to reduce the number of technologies for each general response action that undergo the final technology screening (as presented in Section 6) so that only the "most viable" options given the specific site conditions are carried into the detailed comparative analysis (Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act, EPA, 1988). Thermal desorption did not rise to the same level of viability as those technologies that were retained in Section 5. No revision to the SFS Report is necessary to address this comment.

3. **Section 5.4.5.2, Surface Water Disposal.** The text states that this option was eliminated because "…additional requirements may be required by an NPDES to reduce the maximum daily load (MDL) of orthophosphate being discharged." The text should state what those **requirements** are and also demonstrate that this option is not technically implementable. As stated, the option should be retained for consideration in the final screening of technologies (and potentially the detailed analysis of alternatives).

   FMC Response: As discussed during the March 30 and 31, 2010 EPA, agency and FMC meeting, the second bullet (Surface Water) in Section 5.4.5.2 has been revised as follows to add a more detailed description of the significant administrative and technical issues associated with a new NPDES permitted discharge to the Portneuf River:

   > ***Surface Water*** *– Discharge to the Portneuf River would require a National Pollutant Discharge Elimination System (NPDES) permit that would stipulate the flow rate and concentrations of constituents that could be discharged. Following permanent plant shutdown, FMC officially terminated its former NPDES permit (ID-000022-1) in October 2002. Thus, a completely new NPDES permit would be required as opposed to discharge under an existing or modified permit. Significant administrative and technical issues would be encountered to obtain a new NPDES permitted discharge to the Portneuf River due to its impaired water quality status on Idaho's current §303(d) list, including carryovers from previous lists (2002, 1998, and 1996), and also revisions to assessment units with approved TMDLs (Portneuf River TMDL Revision and Addendum - October 2009, IDEQ, 2009). Among other pollutants (e.g., total suspended solids, E. Coli bacteria), the Portneuf River is listed as impaired for the nutrients total phosphorus and nitrogen that are constituents in FMC-impacted groundwater. IDEQ worked with numerous stakeholders including the Portneuf Watershed Advisory Group to develop / revise the waste load allocations presented in the October 2009 Portneuf River TMDL Revision and Addendum and is working to complete the multi-year process to finalize the TMDL revision. Any new discharges would require further revision to the waste load allocations and, according to IDEQ, a "new" round of negotiations on waste load allocations and revision to the TMDL would require 1 to 2 years. Further, IDEQ currently does not have staff resources to begin another "round" of revision to the TMDL which could further extend the timing.*

Treatment of extracted groundwater to reduce total phosphorus and nitrate to meet an IDEQ-stakeholder negotiated waste load allocation for a new NPDES permitted discharge may be technically infeasible or at a minimum very costly compared to other disposal options. As a result, discharge to surface water is eliminated from further consideration.

4. **Section 6.1.2.1, Pages 6-4 and 6-5.** There are two "EPA Report Finding No. 3" entries.

   FMC Response: Corrected.

5. **Section 7.1.1, Consideration of Principal Threat Waste in the SFS.** Although this section provides the reader with an interesting discussion of FMC's views on the subject, it does not belong in the SFS and should be removed.

   FMC Response: Text has been changed to the language regarding Principal Threat waste that was presented in the EPA Region 10 position paper to the EPA National Remedy Review Board. Specifically, Section 7.1.1 has been revised with the following language:

   The NCP has established an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP §300.430(a)(1)(iii)(A)). Where EPA determines that it is not practicable to use treatment to address principal threat source materials (PTSM), they may be transported offsite, consistent with the Off-Site Disposal Rule, 40 CFR 300.440, or managed safely onsite, consistent with ARARs and risk-based action levels.

   EPA has designated elemental phosphorus (P4) in subsurface soils and underground process piping as a PSTM at the FMC Plant OU due to the potential for future exposure (due to intrusive excavation activity) in specific RAs. The following RAO was developed to address P4 as a PTSM:

   > *"Prevent direct exposure to elemental phosphorus under conditions that may spontaneously combust, posing a fire hazard, and resultant air emissions that represent a significant risk to human health and the environment."*

   The NCP and EPA's 1991 guidance indicate that there may be situations where wastes identified as PTSM may be contained rather than treated, or be given limited treatment, due to difficulties in treating the wastes. Specific situations where this may be the case include the following:

   - *Treatment technologies are not technically feasible or are not available within a reasonable time frame;*
   - *The extraordinary volume of materials or of the site make implementation of treatment technologies impracticable;*

- *Implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation; or*

- *Several effects across environmental media resulting from implementation would occur.*

The SFS process included a rigorous review and evaluation of potential P4 treatment alternatives. For the following reasons, EPA has determined that it is technically infeasible to treat subsurface P4 within RA-B (including in the capillary fringe) and RA-C and that human health and the environment can be adequately protected through containment:

- *Based on EPA's Office of Solid Waste and Emergency Response report entitled "Treatment Technologies for Historical Ponds Containing Elemental Phosphorus – Summary and Evaluation" (EPA, 2003), FMC's update of the EPA 2003 technology evaluation doscumented in "Identification and Evaluation of P4 Treatment Technologies – January 2009" (MWH, 2009c), and the U.S. Army Corp of Engineers P4 treatment technology review and evaluation documented in "Remediation of P_4 Contaminated Matrices at FMC, Pocatello, Idaho – January 2009" (USACE, 2009), there are no technically feasible P4 treatment technologies available or likely to become available in the near future for treatment of the volume and type of P4 contaminated materials (soils and fill) at the FMC Plant Site.*

- *The predominant hazard associated with P4 is the potential for spontaneous oxidation to cause acute thermal burns to anyone coming into direct contact with this material. For all RAs where P4 is present, it is below the ground surface and direct exposure could only occur if the P4 were excavated.*

- *Containment in place has been the primary selected remedial action at similar sites, including TVA sites and the Stauffer Chemical Tarpon Springs site. Containment of elemental phosphorus wastes through installation of low-permeability covers also has specifically been approved by EPA and implemented at the FMC Pocatello facility for RCRA closure of elemental phosphorus-containing process waste ponds.*

EPA has considered removal and treatment of PTSM in underground process and sewer piping, due to the relatively shallow depth of the piping and relatively lower estimated volume of potential residual P4 material contained within the piping. The following describes EPA's evaluation of potential treatment alternatives for this PTSM.

Underground Process Piping

Under Soil Alternatives 2, 3 and 4, the underground process piping will be contained beneath an ET cap. While the statutory preference for treatment of a PTSM would not be attained, this approach is consistent with the NCP and EPA's 1991 guidance that there are situations where wastes identified as PTSM may be contained rather than treated. Specifically, implementation of an excavation/treatment-based remedy would result in greater overall risk to human health and the environment due to the risk posed to workers and/or the surrounding community during the construction phase.

Underground Sewer Piping

Under Alternatives 2, 3, and 4, the underground storm sewer piping in RA-A will be cleaned to remove any residual solids and potential P4 and, thus, the statutory preference for treatment of a PTSM would be attained."

6. **Sections 7.4.1.X, Evaluation of the Alternatives, Reduction of Toxicity, Mobility, or Volume.** For each alternative, each of these three factors should be explicitly discussed. For example, for wastes left in place it should be explicitly stated that there is no reduction in toxicity or volume, but there may be a reduction in mobility.

   FMC Response: The current text for alternatives (i.e., Soil Alternatives 2, 3, and 4) in which "capping" is the primary remedial response states, "Mobility of COCs that present threats to groundwater, human health and the environment would be effectively controlled/ eliminated through capping." FMC will add text at the end of this sentence stating "*… although there will be no appreciable reduction in toxicity or volume of COCs in the underlying soils/fill."* FMC will make similar changes elsewhere in the text as appropriate.

7. **Sections 7.4.1.X, Evaluation of the Alternatives, Short/Long-Term Effectiveness.** These sections should include a discussion of what controls and monitoring would need to remain in place in order for the remedy to remain effective over the long term. For example, for caps, fencing would need to be maintained, some system to track deed restrictions would need to be maintained, long-term maintenance on caps needs to occur, etc.

   FMC Response: For each alternative initially evaluated using the EPA criteria of effectiveness, implementability, and cost in Section 7.4.1, there is a detailed description of the soil alternative in the corresponding Section 7.3.X. In each corresponding Section 7.3.X, a more detailed discussion of the soil alternative is presented, including the common/core elements that form the basis for long-term maintenance activities for that alternative. These activities are discussed in detail in Section 7.2.1 – Common/Core Elements of the Assembled Alternatives. FMC will add a sentence in Section 7.4.1 to refer the reader to the corresponding Section 7.3.X for a more detailed description of the soil alternatives.

8. **Section 7.4.2, Soil Alternatives Screening Summary and Selection, last bullet in section.** This bullet should be changed to something other than "grossly excessive costs." For example, the text might read "Although there would be a reduction in toxicity and volume compared to Alternatives 2-4, the costs would be approximately an order of magnitude higher, and would not change the effectiveness of meeting the RAOs or have any effect on protection of human health and the environment."

   FMC Response: FMC's text is a direct quote from EPA's guidance document *Role of Cost in Superfund Remedy Selection* (EPA, 1996) and the NCP (40 CFR 300.430(e)(7)(iii)) and thus is an appropriate description.

9. **Section 7.5, Remedial Alternatives for Groundwater, Page 7-48.** The second bullet states, "There is no migration of FMC site-related constituents in groundwater beyond FMC- (and Simplot-) owned properties…" As discussed in the General Comments, this statement is misleading and inaccurate and should be revised to acknowledge that site-related constituents are diluted by unaffected groundwater prior to migrating off site and discharging to the Portneuf River.

   FMC Response: As described in the response to EPA General Comment #3 above, this bullet conveys important information regarding the extent and transport of the EMF groundwater plume (i.e., no Off-Plant OU wells are site-impacted and potential new Off-Plant OU wells would not encounter EMF-contaminated groundwater). FMC does not believe the statement is misleading because the end of the sentence clearly states that "constituents in groundwater ~~to~~ report as surface water to the Portneuf River" and accurately describes migration of EMF-impacted groundwater into the Off-Plant OU as <u>surface</u> water. However, the bullet does contain a typographical error (per IDEQ specific comment 11) and has been revised to delete "to" between groundwater and report as noted in the quoted text above.

10. **Section 7.5, Remedial Alternatives for Groundwater, Page 7-48.** The third bullet states that there are no domestic or public water supply wells located down gradient. This is not accurate. The domestic supply well(s) on the Rowlands property should be disclosed in this document.

    FMC Response: The third bullet is accurate as written and is taken verbatim from the EPA-approved GWCCR, June 2009 Final. The Rowland well is not located downgradient from EMF-impacted groundwater as evidenced by: 1) over 18 years of EMF groundwater level (elevation) monitoring and evaluations of groundwater flow direction; 2) EMF RI sampling and analyses of the Rowland well (1990-1993) did not find evidence of EMF-impacted groundwater at that well; 3) routine sampling and analysis of monitoring wells 524 and 525 (located over 500 feet south of the Rowland well) shows these wells are at the northern fringe of EMF-impacted groundwater; and 4) EPA's November 2009 sampling and analysis of the Rowland well did not find evidence of EMF-impacted groundwater. However, as discussed during the March 30

and 31, 2010 meeting between FMC, EPA, IDEQ and the Tribes, the third bullet has been revised to include a discussion of the Rowland well as follows:

> *There are no domestic or public water supply wells located downgradient of site-impacted groundwater. The Rowland well is the nearest cross-gradient domestic well and is located over 500 feet north of EMF monitoring wells 524 and 525 located at the northern fringe of EMF-impacted groundwater. Collectively, groundwater level / flow direction monitoring, analytical results from water samples from monitoring wells 524 and 525 and analytical results from water samples from the Rowland well over a period spanning from 1990 to 2009 demonstrate the Rowland well is not impacted by EMF-sources and, given its distant cross-gradient location, is highly unlikely to be impacted in the future.*

11. **Section 7.5.4, Groundwater Alternative 2B, Page 7-54.** In the second paragraph the MCL for arsenic is incorrectly stated as 10 mg/L. It should be corrected to 0.01 mg/L. There are also other locations in the document with this error.

    FMC Response: Corrected.

12. **Section 7.6.2, Groundwater Alternatives Screening Summary and Selection, Page 7-74.** Groundwater Alternatives 3A and 3B should be retained and carried into the detailed analysis of alternatives.

    FMC Response: As discussed during the March 30 and 31, 2010 meeting between FMC, EPA, IDEQ and the Tribes, FMC believes the information presented in the detailed analysis of alternatives fully supports screening out and eliminating groundwater alternatives 3A and 3B from the comparative analysis. As described below in response to the EPA, R. Ross General Comments, FMC evaluated the residual areal extent of contaminants in groundwater, particularly arsenic exceeding the MCL (ARAR), as the most relevant comparison of the predicted performance of groundwater Alternatives 1, 2 and 3. We believe this is the most relevant measure because regardless of the residual arsenic concentration in groundwater at the site, the groundwater within the area of arsenic above the MCL of 0.01 mg/l meets neither the arsenic ARAR nor the RAO for restoration of groundwater. In response to that comment, FMC did calculate and compare the predicted mass removal performance of groundwater Alternatives 1, 2 and 3 (in addition to the performance based on residual areal extent of impacted groundwater presented in the draft SFS Report). The residual mass was calculated based on the sum of the modeled concentration in all four (4) model layers and the performance of groundwater Alternatives 1, 2 and 3 were compared based on the percent reduction in mass for arsenic, total phosphorus / orthophosphate, and potassium in groundwater at the 25, 50 and 100 year time steps. The residual mass was calculated for the FMC Plant Site only (as was the residual areal extent) to minimize effects from the assumptions for the Simplot Plant OU and areas downgradient from both sites toward the Portneuf River. The result of the relative predicted decrease in residual mass of arsenic is summarized below:

Arsenic:

- After 25 years, Alternative 2 had 1 percent less mass, and Alternative 3 had 9 percent less mass, than Alternative 1.
- After 50 years, Alternative 2 had 1 percent less mass, and Alternative 3 had 13 percent less mass, than Alternative 1.
- After 100 years, Alternative 2 had 2 percent less mass, and Alternative 3 had 18 percent less mass, than Alternative 1.

The predicted incremental reduction in the mass of arsenic in groundwater at the FMC Plant Site under Alternatives 2B and 3B show the same lack of significant difference in the predicted reduction in areal extent of arsenic above the MCL when compared to Alternative 1 as shown below:

Groundwater Alternative	Incremental Reduction Arsenic Areal Extent Vs. Alternative 1			Incremental Reduction Arsenic Mass Vs. Alternative 1		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	-	-	-	-	-	-
2	1%	0%	2%	1%	1%	2%
3	2%	4%	11%	9%	13%	18%

As described in the response to the EPA, R. Ross General Comments, the SFS has been revised to describe the evaluation and results of the estimated residual mass in groundwater for the groundwater alternatives. These text changes have been made in Section 7 regarding groundwater Alternatives 1, 2 and 3, and in Section 8 in the comparison of groundwater Alternatives 1 and 2. The evaluation of groundwater alternatives based on residual mass provides additional information supporting elimination of Alternatives 3A and 3B at the end of the detailed analysis (Section 7) of the draft SFS Report. FMC has not revised the SFS to include groundwater Alternatives 3A and 3B in the comparative analysis.

Draft Comments on the
Draft Supplemental Feasibility Study Report
For the
FMC Plant Operable Unit – March 2010
Marianne E. Walsh

1. The whole discussion of the hazards associated with the excavation of P_4 contaminated soils ignores an important physical property of P_4. If FMC applied the same hazard analysis to the manufacturing of P_4, they would never have produced P_4. P_4 as a gas or liquid is extremely hazardous (pyrophoric). P_4 as a solid in the ground is far less likely to auto-ignite if temperatures are low (the autoignition temperature ranges from 20 to 40°C). To safely excavate P_4 contaminated soils, P_4 must be prevented from transitioning from a solid to a vapor. Excavation of soil and piping at temperatures well below the auto-ignition temperature of P_4 was not considered as a option. Note that the excavated matrix must be cold, not just the air temperature.

   FMC Response: While FMC does not dispute the premise that P4 is less likely to spontaneously ignite during cold conditions than during warm/hot conditions, decades of experience at the FMC Pocatello facility have shown that full-scale excavation of P4-containing wastes as would be required for site remediation is not practical during winter months. The concept to "safely excavate P4-contaminated soils" at "temperatures well below the auto-ignition temperature of P4" ignores a number of important practical considerations, including:

   - The "construction season" in southeastern Idaho is typically from April until November. The obstacles presented by winter conditions would greatly complicate a large-scale construction (or excavation) project. For example, as described in Section 5.2.4 of the *SFS Report*, modified excavation techniques would be required, including use of significant quantities of water to minimize the spontaneous ignition of exposed P4. Implementing these modified techniques would be impractical during winter months.
   - Conversely, attempting to excavate only during the winter months, if deemed necessary, would significantly shorten the annual period during which excavation could be done and delay the remedial action.
   - It is unclear how the statement "*Note that the excavated matrix must be cold, not just the air temperature*" would be accomplished on the scale of a large excavation project.
   - While P4 is less likely to spontaneously ignite during cold conditions than during warm/hot conditions, P4-containing fill materials as would be encountered during excavation at the site actually become much less predictable during cold weather, and therefore, more dangerous to handle. Experience of handling such P4-containing materials during cold weather has shown that any mechanical action, such as digging, scraping, boring, or pushing such materials, will cause spontaneous ignition due to localized friction. Once a small localized area ignites, the P4-oxidation reaction quickly spreads through the rest of the P-4 contaminated matrix. Given that such

reactions are much less predictable during cold weather, this scenario is more dangerous to site workers.

No revision to the SFS Report is necessary to address this comment.

2. The discussion of thermal desorption does not consider the relatively high vapor pressure of P_4 for a semi-volatile. A temperature range (30 and 44°C) required to transfer the bulk of the solid P_4 to the vapor phase is much less than the temperatures used for most organic contaminants.

   FMC Response: See the response to EPA Specific Comment #2 above. No revision to the SFS Report is necessary to address this comment.

3. Was recovery of P_4 as a marketable product ever considered? If not, why not?

   FMC Response: As discussed in the report entitled *Identification and Evaluation of P4 Treatment Technologies – January 2009* (MWH, 2009) and in Section 5 of the *SFS Report*, FMC identified and evaluated all P4 treatment technologies available in the literature. These technologies are consistent with those discussed in EPA's report entitled *Treatment Technologies for Historic Ponds Containing Elemental Phosphorus – Summary and* Evaluation (EPA, 2003). Some of these technologies are amenable to P4 recovery as a marketable product, i.e., thermal desorption and the pot still. In cases where these technologies have been demonstrated, the feed concentration ranged from pure P4 (as in the case of munitions processed using thermal desorption) to >20% P4 (as required in the pot still). While small pockets of >20% P4 may exist within the soil/fill at the FMC Plant OU in RA-B or RA-C, excavated material from these areas (and all other areas suspected of containing P4) would be expected to contain less than 10% P4 on average. While large volumes of P4-contaminated soil/fill have been estimated to potentially be present in RA-B and RA-C, once excavated, these P4-contaminated materials would not present an acceptable feed to these technologies that would allow for P4 recovery as a marketable product. No revision to the SFS Report is necessary to address this comment.

4. The FMC Pocatello plant was the largest P_4 manufacturing site in North America, and, if the estimates of the mass of P_4 are accurate, they will be leaving an unprecedented amount P_4 in the subsurface soils under a cap. The long-term fate and transport of such an enormous source of P_4 is unknown. Given that freshwater benthic communities are adversely affected by P_4 concentrations greater than 0.002 µg/g (Sullivan et al. 1979), a rigorous long-term groundwater monitoring program will be required to ensure migration of P_4 is not a concern. This program must include analytical methods that provide sufficiently low detection limits (not visual observation of "smoke").

   FMC Response: The commenter may not be aware that FMC has been sampling and analyzing groundwater at the site for elemental phosphorus since 1998. FMC's RCRA groundwater monitoring includes routine groundwater monitoring for elemental

phosphorus and has over 10 years of results for analysis of groundwater samples for elemental phosphorus. Those results are detailed in the GWCCR, June 2009 Final. All groundwater samples have been and will be analyzed for elemental phosphorus by EPA method 7580 (SW-846) so we do not understand the commenter's reference to a "visual" method. EPA method 7580 for water samples is capable of routinely achieving sensitivity on the order of 0.01 µg/liter (low level procedure) and 0.1 µg/liter (higher level procedure). FMC's current laboratory routinely achieves a method 7580 detection limit of 0.05 µg/liter. No revision to the SFS Report is necessary to address this comment.

Comments of FMC/MWH March 2010 DRAFT
Supplemental Feasibility Study (SFS)
David J. Reisman, ORD, EPA

General Comments:

1. It is confusing for this reader to have FMC/MWH keep changing the landscape. First, it is 23 or 24 RU's, and then it is 11 RAs. Personal preference, mainly. No issue per se. As personnel get involved at later stages on the site, this type of separation and classification may make it easier for remediation, but not for review.

   FMC Response: As presented in the *Scoping and Planning Memorandum – February 2004*, 23 Remediation Units (RUs) were identified based upon process areas and associated solid waste management units (SWMUs). These RUs were established to facilitate the supplemental remedial investigation (SRI) that was designed to fill data gaps. During the development of the *SRI Work Plan*, areas outside of these 23 RUs were identified that did not contain SWMUs but potentially could have been impacted by site operations. These areas immediately around plant operations were lumped into a site-wide, non-contiguous remediation unit - RU 24. Other areas identified for further investigation to fill data gaps included the northern properties (north of highway 30) and the southern and western undeveloped areas. These new areas for investigation were approved by EPA with the acceptance and approval of the *SRI Work Plan* and *SRI Work Plan Modifications.*

   After completion of the SRI, it was recognized by EPA and FMC that many RUs (or portions of RUs) with similar characteristics would best be combined together to facilitate the supplemental feasibility study (SFS) and subsequent RD/RA. Therefore, it was agreed to recombine RUs into 14 remediation areas (RA-A, RA-A1, RA-B, RA-C, RA-D, RA-E, RA-F, RA-F1, RA-F2, RA-G, RA-H, RA-I, RA-J, and RA-K). The transition from RUs to RAs was presented in Section 3.5 of the *SFS Work Plan* and subsequently approved by EPA. No revision to the SFS Report is necessary to address this comment.

2. In at least two places within the document (5.2.4 and 6.2.4), the title of the heading included "Reuse." However, there was no provided information on reuse or waste recycling opportunities. For example, Pond 165 has an off gas, phosphine, which can probably be utilized in the J. R. Simplot operation, but it is not discussed or considered within the SFS. RIR is a different type of "Reuse."

   FMC Response: In Sections 5 and 6 of the *SFS Report*, remedial technologies for each medium are presented and screened before they are assembled into alternatives in Section 7. Reuse in this context, and in these sections, is contrasted with removal and disposal of site-impacted materials (i.e., containing COCs). FMC discusses opportunities for reuse of site materials in the initial presentation of the remedial alternatives for soil in Section 7 and in the detailed analysis of remedial alternatives in Section 8 of this report. For example, slag from RA-F is likely to be used (or reused)

throughout the site for building up the site grade prior to capping. Another example would include the potential use (or reuse) of surface soils excavated from RA-J to provide capping material (either as sub base or soil cover material) for the gamma cap to be constructed in RA-A. No revision to the SFS Report is necessary to address this comment.

3. With the Reuse comment above, I am not sure how to work the "Receptor-Initiated Remediation (RIR)" program into the site remediation plan. This issue needs substantial discussion and possible re-working.

   FMC Response: See Response to EPA General Comment #1. No revision to the SFS Report is necessary to address this comment.

4. In some instances with various remedial approaches, there is discussion of minimizing phosphine formation by using a water barrier. FMC does not provide details as to how this barrier ("blanket") will be achieved, especially during any site excavation. We heard the same discussion in our work at Tarpon Springs in Region 4. It did not work well. Details must be part of the documentation.

   FMC Response: FMC does not propose anywhere in the *SFS Report* to use water as a "barrier" to minimize phosphine formation. In fact, the site conceptual model presumes that phosphine is typically formed from the hydrolysis reaction of P4 and water. Rather, FMC has pointed out in Sections 5.2.4.1 and 6.2.4.1 that large quantities of water would be required during excavation of P4-contaminated fill/soils to prevent the direct contact of P4 with air and thus prevent oxidation of P4 (burning) to P2O5. This is typically done by flooding the excavation site with water as well as keeping all excavated material saturated with water. Furthermore, excavated fill/soil containing P4 would likely need to be stored, transported, prepared for treatment, and treated within a water slurry to further prevent P4 oxidation. Using water to blanket P4 has always been the standard operating procedure within P4 manufacturing/processing facilities.

   These excavation, storage, transport, and preparation operations would likely result in the P4/water hydrolysis reactions, generating phosphine that would need to be captured and treated. At the Tarpon Springs site, in-situ stabilization/solidification of P4 was attempted. The resulting P4 and phosphine reactions, which could not be easily controlled underground once they started, created substantial releases of phosphine, phosphorus pentoxide, and other phosphorus compounds. FMC is acutely aware of the need to prevent such occurrences. As such, the technology evaluations considered the potential impacts to human health and the environment and the extreme measures required, in some cases, to prevent similar scenarios. No revision to the SFS Report is necessary to address this comment.

5. There are questions regarding the depth issue for P4. If excavation is limited to 10' – 15', a substantial amount of P4 will not be located or removed. For the remedial

alternatives (Chapter 5-7), it would be helpful to show how much each option removes, of the estimated 18 million cubic yards (page 5-11).

FMC Response: Table 2-1 presents the types of fill, estimates of total fill volumes, and the range estimates of P4 in each RU. These range estimates of P4 in each RU are strictly estimates: the potential safety and health threats to SRI field personnel did not warrant soil investigation to more precisely determine how much P4 each RU contained. Given these P4 estimates, it was not deemed necessary or appropriate to estimate the total P4 that would be removed and treated for each of the soil alternatives. However, the following general comparisons can be made:

- Soil Alternative – No Action – would not remove any P4.
- Soil Alternatives 2, 3, and 4 would remove and treat similar volumes of P4, i.e., the P4 in the underground storm sewer would be removed and treated off-site.
- Soil Alternative 5 would remove and treat all P4 associated with underground storm sewer and process piping, all of the P4 in RU 22b (historical CERCLA ponds), all of the P4 in RU 22c (railroad swale), and 10 to 20% of the P4 in RUs 1 and 2.
- Soil Alternative 6 would remove and treat all P4 on the FMC Plant OU including all P4 associated with the underground storm sewer and process piping, RU-F1(buried railcars), RU 22b, RU 22c, and RUs 1 and 2.

No revision to the SFS Report is necessary to address this comment.

Specific Comments:

1. Page 2 – 15. Pond 85 Recovery Process (mid-1980's – 1993). Please discuss this process and if it worked, why is it not being considered as an alternative?

   FMC Response: The Pond 8S Recovery Process was started up in late 1981 and was operated intermittently through 1992. This process involved using a floating dredge to remove P4-containing pond sediments (as a slurry) followed by processing through hydroclones and a centrifuge. The resultant P4-enriched product was then processed in the P4 manufacturing plant by distillation within one of the operating P4 furnaces. The waste stream from the process, consisting of phossy water that had 1% to 5% P4, was sent to one of the existing RCRA ponds (prior to RCRA pond closure). The Pond 8S Recovery Process was not considered as a viable P4 treatment/recovery technology for the SFS for the following reasons:

   - Pond 8S had the highest concentrations of P4 of any of the active waste ponds, with P4 concentrations estimated as high as 30%. None of the RAs considered for P4 excavation/treatment approach this P4 concentration.
   - The Pond 8S Recovery Process required that a floating dredge be used to recover the P4 wastes. None of the RAs are currently "active," i.e., they were all dewatered and "closed" prior to 1981. Flooding any of these areas to allow for a

floating dredge to be operated would create a significantly increased threat to groundwater.

- The "product" stream from the Pond 8S Recovery Process is not a marketable product, but must be further processed, i.e., distilled in an operating P4 furnace.
- The Pond 8S Recovery Process generates a waste stream that is very similar to materials in the historical CERCLA ponds being considered for remediation.
- The Pond 8S Recovery Process was never considered to be a "success" and was never attempted anywhere else at the FMC facility or at any other site.

No revision to the SFS Report is necessary to address this comment.

2. Page 2 – 15. The discussion in this document regarding recovery (Reuse) should be further evaluated. For older ideas in this area, please see:

   Edwards, R.E., O.E. Moore, & J.M. Sullivan. Recovery of Phosphates from Elemental Phosphorus Bearing Wastes. *"Emerging Technologies in Hazardous Waste Management."* American Chemical Society. 1993. Symposium (I & EC Division). Atlanta, GA. Available via Internet.

   FMC Response: See response to Marianne Walsh comment #3 above. No revision to the SFS Report is necessary to address this comment.

3. Page 2 – 9. Why is RU 6 not considered in some of these lists? Were there no spills in a tank area? That would be rare.

   FMC Response: While process knowledge indicated that some phossy water spills likely occurred during operation of the long-term P4 storage tanks in RU 6, a comprehensive and specific investigation performed during the SRI did not find any existing contamination from those spills (SRI Report, Section 4.6). Any P4 associated with past spills is presumed to have been oxidized, and any metals and radionuclides associated with such spills are indistinguishable from these same constituents present in the slag that currently covers the area. The area (now part of RA-A) is proposed for remediation to address gamma exposure. No revision to the SFS Report is necessary to address this comment.

4. Page 2 – 18. Was there a trench dug for the tank cars, and how were they loaded before burial in 19c? Was the material in drums, if so, what type? If this information is in the Appendix, please ignore as I have not made it through the appended documents. This area will be a continual source of phosphorus; it is difficult to leave in place (as is) in any remediation scenario unless the material cannot move vertically or horizontally. FMC has not presented data to show this latter issue to be possible.

   FMC Response: The memorandum entitled, *Buried Railcar Evaluations for the FMC Plant Operable Unit* (MWH, 2009), provides the background information regarding the railcar placement and burial. This memo is provided for review in Volume 2 - Apendix B of the *SFS Report*. As explained in the memo:

- The phosphorus, which originated as P4 sludge in the P4 manufacturing process, was placed in railcars for storage and later removed and recycled to the process. Twenty-one railcars could not be completely cleaned of P4 sludge and therefore could not be put back into fleet service. These railcars had their trucks (wheels) removed and were taken to the south edge (at the time in 1964) of the slag pile. The railcars were placed on the ground surface, covered with soil, and subsequently covered with the advance to the south of the slag pile working face.

- Given the depth of the railcar burial in slag, the railroad cars do not pose a human health or ecological risk. A remedial action decision to cap the slag pile, augmented by institutional controls prohibiting intrusive activities in the area of the rail cars, would provide additional protection against potential human health or ecological risks.

- No EPA exposure scenario anticipates human exposures to COCs at depths of 80 feet, or more, below grade. The final grading plan for the slag pile should continue to maximize total depth of coverage.

- Capping is a proven, accepted technology as shown in Table 1-1 of *Identification and Evaluation of P4 Treatment Technologies – January 2009* (MWH, 2009), including burial and capping of derailed phosphorus product cars in Fairfield, California.

- The railcars, even if they have leaked or will leak in the future, do not pose a threat to groundwater as P4 does not migrate when at ambient or subsurface soil temperatures. As documented in the GWCCR, the slag pile (RU 19) and buried railcars (RU 19c) are not identified as sources of elemental phosphorus or elevated total phosphorus / orthophosphate in groundwater downgradient from these RUs. A final remedy for the slag pile is expected to include a focused groundwater monitoring program for this unit and the nearby old plant solid waste landfill (RU 19b).

- A cap placed on the graded slag pile, along with appropriate institutional controls, will assure protection against any potential threat to groundwater.

No revision to the SFS Report is necessary to address this comment.

5. Page 2 – 19 Please explain the sentence regarding a leaking line being detected immediately. How could a line underground be detected immediately?

   FMC Response: The CO line came from the furnace off-gas and contained primarily CO (a P4 reducing reaction by-product) and P4. Any leak of the CO line was immediately ignited when the P4 came into contact with air. The leak was immediately detected as result of the burning CO at the surface. FMC will modify the

statement on Page 2-19 to read: "While this CO line may contain a small quantity of fairly pure P4, the CO line most likely did not leak because a leaking CO line would have been detected immediately *as evidenced by the burning CO/P4 at the surface*."

6. Page 4 – 1. What is SIS? Not on page X of abbreviations.

   FMC Response: Corrected to read "RIR."

7. Page 5 – 10. Cores: The issue of measuring P4 in cores needs some discussion. It appears that P4's presence was determined by smoking or not smoking. Were any other measurements taken when the cores were lifted from the ground? Is there science behind these statements?

   FMC Response: The SRI investigation, in areas where P4 was suspected or known to be present, was designed on the premise that P4 areas would be capped. Thus the investigation in these areas was for "cap delineation." This approach and the rationale for it are presented in the *SRI Work Plan – May 2007* and the *SRI Report – May 2009*, both approved by EPA. "Smoking" was used only to confirm the presence of P4, and that the remedial approach (capping or otherwise) would have to address the presence of P4. In the case of areas identified for likely capping, the investigation included step-out soil borings to identify where P4 was no longer detected, with the goal that these boring locations could be used to establish the cap perimeter. The final step-out boring (typically 40 feet beyond the last boring that indicated the presence of P4) was submitted to the laboratory to analyze for P4 (and other COCs) to confirm the absence of P4. Therefore, the outer edge of the area containing P4 was confirmed through analytical data and through smoking or other visual means. No revision to the SFS Report is necessary to address this comment.

8. <u>Chapter 5.</u> In general – agree. Specifics do not agree with several issues (TBD – to be discussed). For example, incineration vs. thermal description - I missed the logic of eliminating one while keeping the other. Please explain. Please include caustic hydrolysis in this discussion. I do not know the regulatory process and the ability to institute controls on Tribal land. I will leave this issue to the region and the tribe.

   FMC Response: See response to EPA Specific Comment #2 above. No revision to the SFS Report is necessary to address this comment.

9. <u>Chapter 5-7.</u> Receptor Initiated Remediation (RIR) - A very interesting concept but a bit too idealistic in terms of a P4 – metals site. For any party to buy into this concept at the EMF site, one would have to see some proposed re-development plan. What my point is: What type of re-development would work in this area, in Pocatello, Idaho, especially considering the economy? Will this area just be fenced with limited access to capped area? Even if this option is considered, what is the future of this option? Will the P4 degrade over time? Will it move laterally or vertically towards ground water over the next 20 years? Other than a suggested idea, there is not even a weight of evidence approach used to support this alternative. In addition, is there other

available land that a developer would select? Probably so, and they would not have the liability concern. This issue on re-development is outside my expertise, so let me get back to science and engineering.

FMC Response: See response to EPA General Comment #1 above. No revision to the SFS Report is necessary to address this comment.

10. Chapter 7. Several different treatments and remedial options will be required to "close" this site. I do not believe one technology or solution fits the entire site, and I think the alternatives tend to agree with this point.

    FMC Response: Agreed. Each of the assembled soil alternatives uses a variety of technologies to remediate the site. Table 7-2 illustrates the variety of technologies and process options that have been considered for each RA under each of the alternatives. For example, RA-K (the Railroad Swale) is capped under Soil Alternatives 2 and 3 (ET cap), while under Alternative 4 the contaminated soil/fill in this RA is excavated and consolidated under another ET cap within the same area of contamination. Under Soil Alternatives 5 and 6, soil/fill in this RA is excavated and treated on-site by caustic hydrolysis. No revision to the SFS Report is necessary to address this comment.

11. Substantial perimeter monitoring should be a part of this SFS, and it is not apparent to me how it will be completed (there report does not provide in-depth information). This issue cannot be just visited in the remedial design stage. The essence of FMC's plan must be started with this document as the basis of accepting an alternative may be to use monitoring to assure all stakeholders that if site conditions change, the monitoring will serve as an alert to a condition.

    FMC Response: FMC agrees that capped areas containing P4 will need to be monitored to determine if phosphine is being released at levels that pose a threat to human health and the environment. While FMC has extensive industrial hygiene monitoring experience at the site as well as gas release monitoring experience at the RCRA ponds, FMC recognizes that the cap monitoring program will likely be different for the P4-containing areas proposed to be capped under the CERCLA program. FMC and EPA are currently developing a site-wide investigation of phosphine (and other gases of potential concern) to be performed during 2010. It is likely that the approach, methods and results of this investigation will inform the design of the long-term phosphine monitoring program at the areas proposed for capping. FMC plans to develop and include the specifics of this cap gas emissions monitoring program as part of the remedial design (RD) document that will require EPA review and approval. That monitoring program will meet the goal stated in this comment of assuring "all stakeholders that if site conditions change, the monitoring will serve as an alert to a condition." As this will be addressed in the RD, no revision to the SFS Report is necessary to address this comment.

12. I got lost somewhere between Principal and Threat Waste. I really don't understand this discussion. In 31 years in the EPA, I haven't seen this type of discussion in a feasibility-type document.

FMC Response: See response to EPA Specific Comment #5.

Review of Soil Alternatives for FMC in "Supplemental Remedial Investigation/Feasibility Study" with emphasis on ET cover applications
EPA, Steve Rock

General Comments:

This review concentrates on the ET and Soil cover aspects of the proposed alternatives.

Assumptions: In general the climate and available soil predict that an ET cover will work well in the area of the site. Tests in similar climates show that the performance of a properly sized and installed ET cover is predictable and successful in reducing infiltration, so the basic assumptions of the Supplemental RI/FS are sound. ET covers will perform as expected in this document, supported by the research and documentation in the Capping Report, Appendix D.

A proper ET cover system will need site specific design and installation. This in turn cannot be done until the extent of the application is determined; the size of the cover or covers will influence the availability of borrow material and potentially the quality or expense of that material. Thus the process of design, proposal, and review is to some degree iterative. This review of this document assumes that there exists enough appropriate soil that can be obtained and transported economically to the site to support the costs enumerated in this document.

General: The proposers have a solid understanding of various capping options and have neither oversold nor underestimated their cost and capabilities. The sections regarding capping show knowledge of the literature and current understanding of various capping technologies, their applications and limitations. These documents do a good job of tackling a complex set of RAs, technologies, and goals. There are occasional small errors of writing and numbering that in no way detract from the overall message of careful study, deliberate thinking, and good faith effort to find an acceptable solution. The writing is clear, concise, and well organized.

> **FMC Response:** FMC appreciates this feedback. No revision to the SFS Report is necessary to address this comment.

Specific Comments:

5.2.3.1 The descriptions of the technology options is clear and accurate.

> **FMC Response:** FMC appreciates this feedback. No revision to the SFS Report is necessary to address this comment.

5.2.3.3 Surface controls are crucial to successful capping, especially in the climate of the site which is subject to occasional extreme weather events. All containment designs will have this incorporated, although it should not stand alone as an option.

FMC Response: Agreed. The surface controls as described in Section 5.2.3.3 are not intended as a "stand-alone" remedial approach, but as a "process option" that is an integral part of a larger remedial approach. Surface controls, along with other common/core elements, are discussed in Section 7.2.1 and will be integrated as appropriate into all selected remedies. No revision to the SFS Report is necessary to address this comment.

6.2.3.1 It is appropriate to retain the various capping options on technical merits. The descriptions of the aspects of protectiveness of an ET cover in this section summarize the longer descriptions and arguments in Appendix D, all of which seem well researched, reasoned, and presented. The gas diffusion case as presented here and in Appendix D suggests a new approach to gas management and is compelling but may need some confirmatory monitoring.

FMC Response: The "gas diffusion case" is not intended to present a "new approach to gas management," but rather to point out the benefits that may be realized through use of an ET cap that will allow more ambient air transfer into the capped wastes. It is well known that PH3 reacts with oxygen and soils to create much less toxic, naturally-occurring compounds, i.e., phosphates. Gas monitoring is one of the common/core elements, and will be developed as part of the RD and conducted at all the ET caps overlying known or suspected P4-containing materials. No revision to the SFS Report is necessary to address this comment.

The oddly named Soil Cover Cap or gamma cap is actually a thin ET cover. In the cases where infiltration control is not a major goal such a low cost (having both design and installation savings) cover system may be completely appropriate.

FMC Response: While we agree, we would also point out that the gamma cap, where selected as a remedy, is needed only to control gamma radiation. A single foot of soil has been demonstrated to effectively accomplish this. Any reduction in infiltration of surface water may be beneficial, but is not required to meet the RAOs. No revision to the SFS Report is necessary to address this comment.

7.3 Soil Alternatives 2, 3, 4, 5, 6 vary the mix of thin Soil covers, ET covers with Capillary break, and various dig and haul or treat options. This section accurately reflects the technical capabilities of the options in regards to the specific RAs. Based on the cost and effectiveness analysis alternatives 5 and 6 are appropriately removed from further considerations.

FMC Response: Agreed. No revision to the SFS Report is necessary to address this comment.

8.2 Alternatives 2-4 are all acceptable when evaluated against the criterion. The cost analysis is detailed yet based on many assumptions. Costs should perhaps be presented as ranges or with error bars to reflect the uncertainty of the assumptions of the price of fuel, labor etc. The cost variation due to sensitivity to unknowns would be interesting and

perhaps useful. Since these alternatives are very similar this section is neither surprising nor does it definitively eliminate any alternatives.

FMC Response: The cost estimates were conducted with an accuracy of -30% to +50%, consistent with the EPA document entitled "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." While a cost sensitivity analysis may be interesting, FMC believes that the cost variables likely would impact Soil Alternatives 2, 3, and 4 similarly. Therefore, it is likely that cost variability would not impact remedy selection. No revision to the SFS Report is necessary to address this comment.

9.1 The comparisons in this section are accurate and nuanced. Cost and implementability are the only criteria that highlight differences between the Alternatives, so sections 9.1.3.1- 9.1.3.3 delve deeper into specific differences of risk, reuse, and protectiveness. Based on the careful and methodical analysis of the document some combination of thin and capillary break ET appears to be the right choice for FMC.

FMC Response: Agreed. No revision to the SFS Report is necessary to address this comment.

Comments on FMC/MWH draft Volume 1& 2 Supplemental Feasibility Study Report for the FMC Plant Operable Unit of the EMF Superfund Site, Pocatello, Idaho, March 2010.
EPA, Bernie Zavala

General Comments:

The above mentioned document has been reviewed and the majority of the specific comments below focus on the groundwater remedy alternatives and the support documentations. The EPA disagrees with the choice of Groundwater Alternative 1 as recommended by FMC. This recommendation is based on the predictive simulations to meet the remedial action objectives (RAOs). The main rationale for FMC choosing this alternative is based on the modeled 100+ year timeframe for either Groundwater Alternative 2A/B or 3A/B to meet the site RAOs. The transport modeling effort or the predictive simulations used literature values (Kds) and plume matching simulation to make the model converge. Groundwater flow and transport model output aren't unique solutions. EPA was under the impression that these modeling runs would be used to compare the various alternatives and the predictive values should be viewed with caution. If these predictive estimates were to be used as a high valued estimate then site specific data should be collected at the various source areas for the contaminant specific Kd's with the appropriate test being utilized. Also, modeling of the geochemical conditions would be needed for arsenic and phosphorus species. In addition to this chemical modeling and analysis, site specific values for both effective porosity and hydraulic conductivity and other hydraulic parameters at key locations through the model domain must be collected.

If the Groundwater alternative 2A/B or 3A/B was recommended as an interim remedial action and implemented, then the site specific data would have been collected and the aquifer system would have been stressed and a better insight would have been gained on whether or not the RAOs could be obtained within a reasonable time frame. If the data indicates a need for a TI waiver it could be recommended during the five year review process. The following are the specific comments.

> **FMC Response:** Many of the points raised in these general comments are also stated as specific comments and, thus, portions of this response are repeated for those associated specific comments.
>
> As discussed during the March 30 and 31, 2010 meeting between FMC, EPA, IDEQ and the Tribes to review preliminary agency comments on the SFS Report, FMC's recommendation for groundwater alternative 1 is based on the comparative model-predicted performance of the alternatives and not on the modeled greater than 100 year timeframe for groundwater restoration for all of the groundwater alternatives. FMC agreed to revise the text in the draft SFS Report Sections 7 and 8 to emphasize that the model predictions were primarily used to evaluate comparative performance and decrease the perceived overuse of the 100-year model predicted performance timeframe.

While FMC agrees that additional site-specific data would be useful to refine the groundwater flow and transport model, FMC is concerned that EPA is not acknowledging the significant quantity of site-specific data that have been acquired and were used to develop the groundwater model. As described during the EPA-FMC groundwater model meetings and summarized in the Groundwater Model Report, the site-specific data utilized to develop the groundwater model include:

- Geologic data from 103 FMC borings and 57 Simplot borings distributed throughout the model domain but primarily focused within the plant site areas and along flowpaths to the Portneuf River.
- Pump test and slug test results and calculated hydraulic conductivity / transmissivity from 45 shallow zone monitoring wells, 19 deep zone monitoring wells and 16 deep zone production wells distributed throughout the model domain but primarily focused within the plant site areas and along flowpaths to the Portneuf River.
- Precipitation data for the period 1917 to 2008 collected at the Pocatello airport (located within 2 miles of the plant sites), Simplot's estimated recharge rate for the gypsum stack, and Simplot's reported (metered) groundwater production and extraction well pumping rates.
- Portneuf River and associated spring flow data from USGS river gauge stations (1990-2009), EMF RI measurements (1992-1994), IDEQ flow measurements (2000-2002) and data and estimates contained in Simplot's remedial design documents (2008).
- Average 2008 groundwater elevations from 82 FMC monitoring wells, 78 Simplot monitoring wells and surface water elevations at Swanson Road Spring (aka the Spring at Batiste Road) and Batiste Spring for calibration of the groundwater flow model.
- Groundwater quality data, specifically for the modeled parameters arsenic, total phosphorus and potassium from 86 FMC monitoring wells, 33 Simplot monitoring wells and Batiste and Swanson Road Spring for 1994 (initial conditions year for transport model plume matching) and 82 FMC monitoring wells, 58 Simplot monitoring wells and Batiste and Swanson Road Spring for 2008 (plume matching year and base year for the predictive simulations).
- Saturated hydraulic conductivity, moisture content, dry unit weight and specific gravity laboratory results for unsaturated and saturated soil samples and laboratory analysis of saturated soil and water samples for arsenic and total phosphorus collected from borings located proximal to former Pond 8S. These results were utilized by Bechtel to estimate input parameters, including arsenic and orthophosphate sorption (distribution) coefficients (K_d) for the Pond 8S Solute Transport Study (Bechtel groundwater transport model). MWH did not use the laboratory data estimated or final model K_d values used by Bechtel in their groundwater transport model, but the sorption coefficients in the final MWH groundwater model are within reasonable range of the values used by Bechtel. Further, Bechtel did not have the advantage of utilizing 14 years of groundwater monitoring data to perform plume matching ("calibration") of

their groundwater transport model and refine their model transport parameter as is the case for the MWH calibrated groundwater model transport parameters.

Section 1.0 of the groundwater model report has been revised to include the above summary to document the substantial site-specific data that were used in the development of the groundwater model.

Section 2 Site Background – FMC Plant OU

2.4.9 Groundwater Current Conditions Report (GWCCR), Page 2-26

1) The second sentence in the second paragraph should be deleted regarding no migration of FMC and Simplot site-related constituents. The next sentence is accurate regarding the groundwater migration.

FMC Response: The summary of the GWCCR presented in Section 2.4.9, second paragraph was taken verbatim from the GWCCR – June 2009 Final. The second and third sentences were previously revised as requested by EPA based on their comments on the draft GWCCR, October 2008. The second sentence is accurate as written and conveys important information regarding the extent and transport of the EMF groundwater plume (i.e., no Off-Plant OU wells are site-impacted and potential new Off-Plant OU wells would not encounter EMF-contaminated groundwater). FMC does not believe the statement is misleading in that it is followed by the third sentence, which accurately describes the migration of EMF-impacted groundwater into the Off-Plant OU as <u>surface</u> water. No revision to the SFS Report is necessary to address this comment.

Section 5 Applicable Technology Identification and Initial Screening

5.4 Potentially Applicable Groundwater Technologies, Page 5-21

2) Total phosphorus should be added to the list of COCs for the groundwater technologies. Table 4-3 does have total phosphorus for surface water. Total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water.

FMC Response: As discussed during the March 30 and 31, 2010 meeting between FMC, EPA, IDEQ and the Tribes to discuss preliminary agency comments on the SFS Report, FMC disagrees that total phosphorus is a groundwater COC because total phosphorus concentrations in groundwater beneath the FMC Plant Site are not high enough to present a human health risk. There currently are no proposed or final federal or state primary or secondary drinking water standards or any risk-based concentration (RBC) for total phosphorus in drinking water. During the March 30 meeting, EPA indicated that it is developing a RBC for ingestion (drinking) of water for total phosphorus, and that RBC will be in the range of 700 to 800 mg/l. The highest total phosphorus / orthophosphate concentration in groundwater at the FMC Plant Site is at Pond 8S downgradient well 156, which averaged 244 mg/l total phosphorus / orthophosphate based on the four (4) quarters of monitoring during 2009. No revision to the SFS Report is necessary to address this comment.

Section 7 Assembly and Screening of Remedial Alternatives
7.5 Remedial Alternatives for Groundwater, page 7-47
3) Similar to the above comment. Total phosphorus should be added to the list of COCs for the assembly and screening of remedial groundwater alternatives. Table 4-3 does have total phosphorus for surface water. Total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water.

FMC Response: As described in the response to comment 2 above, total phosphorus is not a groundwater COC for the FMC Plant OU. No revision to the SFS Report is necessary to address this comment.

Page 7-48
4) Delete bullet #2, existing bullet #4 better describes the migration of impacted groundwater to surface water or into the Off-Plant OU.

FMC Response: As described in the response to comment 1 above, this bullet conveys important information regarding the extent and transport of the EMF groundwater plume (i.e., no Off-Plant OU wells are site-impacted and potential new Off-Plant OU wells would not encounter EMF-contaminated groundwater). However, the bullet does contain a typographical error (per IDEQ specific comment 11) and has been revised to delete ”to” between groundwater and report.

Page 7-49
5) Alternative 1 must delete “monitored natural attenuation” (MNA) and replace it with long-term-groundwater monitoring. MNA is considered a remedial action methodology and a specific mechanism must be known that either destroys or stabilizes the COCs. Then the mechanism would be known for the attenuation of the COCs within a reasonable time frame.

FMC Response: As discussed during the March 30, 2010 meeting between FMC, EPA, IDEQ and the Tribes to discuss preliminary comments on the draft SFS Report, FMC believes groundwater Alternative 1 is appropriately designated as “Source Controls, Institutional Controls, and Monitored Natural Attenuation.” FMC agreed at that meeting that additional textual description of the in-situ attenuation mechanisms detailed in the EMF RI Report and GWCCR should be summarized in the SFS Report. The following text has been inserted into the SFS Report, Section 7.5.2 (Groundwater Alternative 1) after the first paragraph on page 7-52:

FMC-related constituents are attenuated in the groundwater system by several of the processes described in “Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Directive 9200.4-17P, April 1999). Per OSWER Directive 9200.4-17P: “The “natural attenuation processes” that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under

favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants." The EMF RI (Section 5.3.2 Principal factors affecting migration in the Saturated Zone) and the GWCCR (Section 6.2 Principal Factors Affecting Migration in the Saturated Zone) document that FMC-related constituents are attenuated in-situ by the processes of dilution, chemical stabilization (precipitation) and transformation (oxidation). A brief summary of information presented in the EMF RI and GWCCR follows:

- *The most significant process that attenuates groundwater constituent concentrations is advective mixing (dilution). Mixing of small volumes of FMC-impacted groundwater with large volumes of unaffected groundwater within the EMF aquifer system substantially reduces the concentration of all constituents, including conservative, non-attenuating solutes such as potassium, along the groundwater flowpaths. As reported in the GWCCR, potassium and arsenic concentrations in groundwater immediately downgradient from former Pond 8S average about 700 mg/l and 0.15 mg/l respectively (1996-1998 average at Wells 155, 156 and 157). Approximately 4,000 feet downgradient along the flowpaths and at the northern FMC Plant Site property boundary, potassium and arsenic concentrations in groundwater migrating beyond the FMC Plant Site average about 48 mg/l and 0.027 mg/l respectively (1996-1998 average at wells 111 and 146). This represents a dilution / attenuation factor (DAF) of approximately 15 and 5.6 for potassium and arsenic respectively. The estimated DAF for arsenic is likely conservative (low) due to additional arsenic loading from other former unlined ponds in the western ponds area along the flowpaths to the FMC Plant Site northern property boundary.*

- *Phosphate (total phosphorus and orthophosphate) and fluoride transport is limited by natural attenuation reactions involving the precipitation of calcium and/or iron phosphate solids [Ca3(P04) 2 and FeP04·2H20] and fluorite [CaF2] , respectively. Evidence of precipitation of phosphate solids is supported by comparing the estimated DAF for total phosphorus / orthophosphate with the DAF of potassium and arsenic that are primarily attenuated by dilution along the flowpaths from former Pond 8S to the northern FMC Plant Site property boundary. As reported in the GWCCR, total phosphorus / orthophosphate concentrations in groundwater immediately downgradient from former Pond 8S average about 145 mg/l (1996-1998 average at Wells 155, 156 and 157). Approximately 4,000 feet downgradient along the flowpaths and at the northern FMC Plant Site property boundary, total phosphorus / orthophosphate concentrations average about 2.6 mg/l (1996-1998 average at Wells 111 and 146). This represents a DAF of approximately 55 compared to the estimated DAFs of 15 and 5.6 for potassium and arsenic respectively. The significantly higher*

total phosphorus / orthophosphate DAF (3.5 times the estimated DAF for potassium) cannot reasonably be accounted for by dilution alone.

With respect to fluoride migration, fluoride concentrations were over 1,500 mg/l in former Pond 8S fluids compared with 0.4 mg/l to 0.8 mg/l in representative groundwater. Equilibrium modeling indicates that the groundwater is nearly saturated with respect to fluorite at concentrations of about 0.75 mg/l and, therefore, conditions in the aquifer favor precipitation of the mineral fluorite (SII, 1994).

- *Ammonia is transformed (oxidized) to nitrate as a result of the shift from reducing to oxidizing conditions as the infiltrating fluids (e.g., former Pond 8S solute) mix and equilibrate with the groundwater. As reported in the GWCCR, ammonia concentrations in groundwater immediately downgradient from former Pond 8S average about 5.5 mg/l (1996-1998 average at Wells 155, 156 and 157), but are consistently below detection limits in monitoring wells at the FMC Plant Site northern property boundary and at wells farther downgradient toward the Portneuf River.*

- *Elemental phosphorus (P4) has been routinely detected in groundwater at Wells 108 and 122 downgradient from RUs 1 and 2, but has not been detected at the nearest downgradient Wells 111, 146 and 110 at the FMC Plant Site northern property boundary or any wells farther downgradient toward the Portneuf River. Although the decrease in P4 concentrations to below detectable levels could be due in part to advective mixing, transformations (oxidation and/or hydrolysis) of P4 in groundwater are likely the primary mechanisms whereby the P4 is converted to phosphorus compounds (e.g., orthophosphate).*

Long-term groundwater monitoring (LTM) would be designed to continue monitoring the identified natural attenuation mechanisms in the groundwater system and monitor the performance of the selected source control (soil) remedies to demonstrate that concentrations of COCs decrease over time as predicted by the groundwater model.

7.5.3 Groundwater Alternative 2A- Source and Institutional Controls, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary and Direct Discharge to POTW, page 7-53

6) The third paragraph, picked three monitoring wells and averaged the water quality (MW-110, 146, and TW-9S) as what may be expected regarding the water quality concentrations that will be conveyed to the POTW. These monitoring wells may be outside the influence of the five extraction wells. MW-123, 145,189 should be used instead; these monitoring wells are within the influence of the five extraction wells.

FMC Response: As discussed during the March 30 and 31, 2010 meeting between FMC, EPA, IDEQ and the Tribes, that reviewed preliminary agency comments on the SFS Report, FMC does not agree that the wells suggested in this comment for characterizing the water that would be sent to the POTW are representative of water

quality at the Groundwater Alternative 2 extraction wells. Those wells are too distant from the extraction wells under this alternative and do not account for attenuation of groundwater COCs between the suggested wells and the FMC northern boundary extraction area. However, FMC did evaluate extracted groundwater concentrations with two different sets of wells located within or very close (well 111) to the alternative 2A and 2B northern boundary extraction area. As shown in the summary table below, the average concentrations for the 3 well sets evaluated are essentially the same. Considering that these estimated average concentrations were developed to evaluate the most appropriate treatment methodology to meet the preliminary treatment targets for the A and B water disposal options, FMC does not believe the SFS Report needs to be revised to present a different or alternative set of wells to support selection of disposal options and/or identification of appropriate treatment technologies.

Parameter	Average Wells 110, 146 and TW-9S	Average Wells 110, 111 and 146	Average Wells 110 and 146
pH (Field)	7.01	7.02	6.99
SC (UMHOS/CM)	1521.7	1412.0	1361.5
Redox (mV)	-100.0	-99.6	-100.0
Potassium	43.4	40.4	35.9
Sulfate	168.0	166.7	171.5
Chloride	136.3	130.6	110.9
Fluoride	0.30	0.31	0.41
Ammonia	0.17	0.15	0.15
Nitrate	6.63	6.30	4.97
Orthophosphate/ Total Phosphorus	2.54	2.79	2.21
Arsenic	0.03	0.03	0.04
Flouride	0.34	0.36	0.47
Selenium	0.012	0.012	0.016

Page 7-54
7) The time frames of greater the 100 years should be viewed with caution because of the input data for the transport modeling did not using site specific data.

FMC Response: Consistent with FMC's response to the EPA, B. Zavala General Comments above, FMC agrees to revise the text specified in this comment to qualify the model predictions at the longer-term time steps (beyond 50 years). In addition, SFS Report Sections 7 and 8 will be revised to emphasize that the model predictions were primarily used to evaluate comparative performance. These combined revisions will clarify that the 100-year model timeframe was used primarily to compare the performance of groundwater alternatives rather than make specific predictions

regarding how long a given alternative would need to operate to achieve a given reduction in the residual areal extent or mass of contamination.

7.5.4 Groundwater Alternatives 2B – Source and Institutional Controls, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary, Onsite Treatment, and Discharge to Evaporation/Infiltration Basin, page 7-54
8) More information is needed on why 300 µg/l for total phosphorus is considered background water quality and why the RAO for surface water (water quality criteria, TMDL) of 75 µg/l is not being used? Also, the MCL for arsenic is 10 µg/l not 10 mg/l, please correct.

FMC Response: As discussed during the March 30 and 31, 2010 meeting between FMC, EPA, IDEQ and the Tribes, the SFS Report references 0.3 mg/L as the 95th percentile groundwater background for total phosphorus. This value is documented in the EMF RI Report. This value was used as a preliminary target for identification of water treatment technologies for groundwater disposal option B (percolation / evaporation pond). If EPA selects a groundwater extraction / treatment alternative, details around the final treatment targets and water treatment technology would be developed during the remedial design and remedial action. The second paragraph in Section 7.5.4 has been revised, including correction of the typographical error, as follows:

Groundwater Alternative 2B is the same as Alternative 2A, including a sustained groundwater extraction rate of 530 gpm from 5 wells, except that the groundwater extracted from the aquifer in the northeastern portion of the FMC Plant Site would be: 1) treated for elevated arsenic to the MCL of 10 ug/L and total phosphorus to the 95th percentile background of 0.3 mg/L documented in the EMF RI Report (the other COCs would be below their MCLs or other remedial action standards) and 2) discharged to an evaporation/infiltration basin located in the Western Undeveloped Area (WUA). These treatment targets are preliminary values for identification of an appropriate water treatment technology for this disposal option. If EPA selects a groundwater extraction / treatment alternative, details around the final treatment targets and water treatment technology would be developed during the remedial design and remedial action. Under this alternative, the majority (net of evaporative loss) of extracted groundwater would be reintroduced to the shallow aquifer via the infiltration basin in the WUA. Figure 7-9 depicts the preliminary design location of the extraction wells, the treatment plant, and the infiltration basin based on the hydrologic conditions at the site and the soil remedial alternatives that will use soil from the WUA for capping. The groundwater would be treated by chemical precipitation, and then filtered to meet the remedial action requirements prior to discharge to the WUA evaporation/infiltration basin. Figure 7-6 depicts the process flow diagram for this alternative.

7.5.5 Groundwater Alternative 3A – Source and Institutional Control, Groundwater Extraction for Hydraulic Control at the Plant Site Boundary and at Identified Source Areas, Onsite Pretreatment, and Discharge to POTW, page 7-55
9) Similar to comment #6 above, Table 7-5 should be using monitoring well water quality data from wells within the capture area of the five extraction wells such as MW-123, 145 and 189 for this evaluation.

FMC Response: Please refer to FMC's response to EPA, March 2010, Bernie Zavala Specific Comment #6 above.

Page 7-56
10) The time frames of greater then 100 years should be viewed with caution because of the input data for the transport modeling not using site specific data.

FMC Response: Please refer to FMC's response to the EPA, March 2010, Bernie Zavala General Comment above.

Section 9 Comparative Analysis of Remedial Alternatives
11) The EPA disagrees with FMC's recommendation for Groundwater Alternative 1. See the above general comment for details on this disagreement.

FMC Response: Please refer to FMC's response to EPA, K. Lynch General Comment #2 above that states in part "EPA will document its preferred groundwater alternative in the Proposed Plan and, following the comment period, EPA will document its selected alternative in a ROD amendment for the FMC Plant OU. No revision to the SFS Report appears to be necessary to address this comment."

APPENDIX E Groundwater Model Report

1.0 Introduction, page 1-1
1) Alternative 1, change monitored natural attenuation (MNA) to long-term groundwater monitoring. The Groundwater Current Condition Report, (MWH, 2009b), didn't develop the concept of MNA for the inorganic parameters for the site COCs. It is believe the text meant long-term groundwater monitoring to evaluate the effectiveness of the soil source control.

FMC Response: Please refer to FMC's response to EPA, March 2010, Bernie Zavala Specific Comment #5 above.

Page 1-9
2) There is a concern regarding the input parameters to the flow model regarding the hydraulic conductivities (K). Table 3.3-1 from the EMF RI report should have been included with this document and was not included. More importantly a table of the input parameters for flow model should have been included similarly to Table 2-3 Transport Model Parameters. Figures 2-3 through 2-6 was useful but how does that compare to the know K (ft/day) that was obtained from aquifer testing at the FMC plant? As mentioned in

past modeling meeting K (ft/day) values appear too high. Also, 0.1cm/sec is 283 ft/day not 28 ft/day.

FMC Response: As described in FMC's response to the EPA, March 2010, Bernie Zavala General Comment above, the pump test and slug test results and calculated hydraulic conductivity / transmissivity from 45 shallow zone monitoring wells, 19 deep zone monitoring wells and 3 deep zone production wells are distributed throughout the model domain but primarily focused within the plant site areas and along flowpaths to the Portneuf River. EMF RI Table 3.3-1 is included in Appendix B (EMF Remedial Investigation Tables and Figures) of the Groundwater Model Report. We do not agree that the suggested table of input parameters for the flow model would add value considering that the text already describes the input parameters (e.g., porosity, infiltration (recharge) rates and extraction rates). However, we have developed a table that compares the hydraulic conductivities calculated based on the slug and pump tests (EMF RI Table 3.3-1) to the hydraulic conductivity for the cell and layers in the calibrated flow model associated with the Table 3.3-1 wells located within the model domain. New text has been added to Section 2.3.2 Model Parameters, Hydraulic Conductivity referencing the new Table 2-4 (the other Section 2 tables have been renumbered as needed). The typographical error will be corrected to state 283 ft/day.

APPENDIX G Interim CERCLA Groundwater Monitoring Plan

1.0 Introduction

1.2 Groundwater Monitoring Objectives, page 1-2
1) The EPA appreciates FMC moving forward with an interim CERCLA Groundwater monitoring plan and concurs with the monitoring objectives being the collection of sufficient data of known quality; evaluate potential changes and/or trends in site-related constituents and the overall evaluation of the groundwater conditions on an OU-wide basis. When the EPA does select both a soil and groundwater remedies as part of the ROD amendment for this OU it is likely that additional monitoring wells will be needed other then the one recommended well in the GWCCR.

FMC Response: FMC understands that additional groundwater monitoring wells will be installed as a component of the selected remedial action for the site. The installation and monitoring of 10 new monitoring wells at the site is included in the cost estimates for groundwater Alternatives 1, 2 and 3 in the SFS Report. The exact number, locations and depths of new monitoring wells that will be necessary to support remedial action performance monitoring will be defined during the RD/RA as will the long-term CERCLA groundwater monitoring plan. No revisions to the Interim CERCLA Groundwater Monitoring Plan (ICGMP) appear to be necessary to address this comment.

2.0 Summary of FMC Groundwater Monitoring Programs

2.3.4 Summary, page 2-6
2) It should be mentioned that Simplot will be installing monitoring wells both north and east I-86 (within the groundwater flow path of the FMC OU to the Portneuf River) and the groundwater quality results can and will be useful to the FMC's evaluation of groundwater quality and hydraulics for the FMC OU. It is recommended that the appropriate groundwater data from these new wells be used for the evaluation of the FMC OU.

FMC Response: The last sentence of the first paragraph in Section 4.4 of the ICGMP states: "In addition to the FMC groundwater monitoring program data, the Simplot groundwater monitoring data will be reviewed and evaluated as part of the overall assessment of FMC Plant OU-wide groundwater quality and any trends, primarily in the joint fenceline area and in the area downgradient from both FMC's and Simplot's plant sites." FMC believes this existing text is sufficiently broad to encompass Simplot's current and future monitoring programs including any new wells "in the area downgradient from both FMC's and Simplot's plant sites." However, the following text will be added at the end of the paragraph in Section 2.3.4:

In addition to the FMC groundwater monitoring program data, the Simplot groundwater monitoring data will be reviewed as part of the overall assessment of FMC Plant OU-wide groundwater quality and any trends, primarily in the joint fenceline area and in the area downgradient from both FMC's and Simplot's plant sites, including data from any new monitoring wells installed in these areas.

3.0 Summary of Monitoring Plan components

3.2 Interim CERCLA Monitoring Well Network, page 3-1
3) Please add under the bullet *on-Plant Site wells:* MW-151. Monitoring well 151will help track the down-gradient and lateral boundary of the plume from Pond 8S.

FMC Response: As Well 151 is located within about 300 feet of Pond 8S wells 156 and 157, FMC does not agree that routine monitoring of this well provides significant added value; however, Well 151 will be added to the routine CERCLA groundwater monitoring well network. The groundwater monitoring plan, field sampling plan and quality assurance project plan text, tables and figures have been revised to add Well 151 to the interim CERCLA monitoring well network.

4.0 Evaluation of Data

4.3 Quantitative (Statistical) Evaluation of Results, page 4-4
4) The EPA concurs with the use of the Mann-Kendall Test for trend during this interim groundwater monitoring program. There are two additional areas were the Mann-Kendall test for trend should be included they are the monitoring well for pond 8S and the old phossy pond or the phase IV ponds. The following wells should be included at a minimum: MW-155,156,157, 115, 131 and 114.

FMC Response: As EPA is aware, Wells 155, 156 and 157 (Pond 8S downgradient), Well 115 (Pond 15S downgradient), and Wells 114 and 131 (Phase IV ponds downgradient) are monitored pursuant to FMC's RCRA groundwater monitoring program and the results are evaluated and reported in the RCRA Annual Groundwater Monitoring Assessment report. As described in the ICGMP Section 4.4.1 Summary of RCRA Annual Groundwater Assessment, the annual monitoring results for each of the RCRA units (including these wells) are evaluated using a 3-step statistical test to assess the status of the unit. FMC is concerned that performing a separate test for trend on the data from the suggested wells in the CERCLA evaluation could lead to misinterpretation of the test results because these wells would be "dissociated" from the unit-specific monitoring network (i.e., comparing upgradient and downdgradient wells). While FMC shares EPA's goal of integrating the groundwater monitoring programs at the FMC Plant Site, we believe the timing should be tied to implementation of the selected CERCLA remedial action so that performance monitoring is on a comparable basis (i.e., monitoring the performance of the CERCLA source controls and continued monitoring of the performance of the RCRA final covers). The level of integration suggested by the comment can be addressed during development of the long-term CERCLA groundwater monitoring plan during the remedial design. No revisions are necessary to the Interim CERCLA Groundwater Monitoring Plan to address this comment.

Appendix A
Figure 1.0 Well Locations
5) The Rowland Well in many of the figures may be showing the wrong location. This is the not the same location of the Rowland well that was sampled by EPA in 2009. Please correct this location in future figures.

FMC Response: As indicated by the comment, the Rowland well did not plot in quite the correct location on Appendix A - Figure 1 Well Locations FMC 2Q2008 Monitoring Event. The approximate plotting on that figure was due to transferring the location from a hardcopy figure to Figure 1 (i.e., the coordinates were approximated from hard copy location). The surveyed coordinates for the Rowland well have been confirmed in FMC's data file for well locations and future figures will plot the Rowland well location correctly. Note that the ICGMP well location figures (excluding Appendix A) do not extend north to the location of the Rowland well so no revision of those figures is necessary.

Attachment A - Interim CERCLA Groundwater Monitoring Field Sampling Plan

5.0 Sampling Equipment and Procedures
5.2.1 Water Level Measurements, page 5-3
1) The datum or the location for collecting the surface water elevation must be surveyed and provided in the reports as means sea level (MSL).

FMC Response: A sentence has been added after the bullet list under Section 5.2.1 as follows:

> *The coordinates and elevation above mean sea level of the measuring points for monitoring well (groundwater) and spring (surface water) water level measurements are listed on the table in Appendix A-B.*

A new Appendix A-B will be added to the Interim CERCLA Groundwater Monitoring Plan, Attachment A – Field Sampling Plan that provides surveyed coordinates and measuring point elevations for the monitoring wells and springs listed in the bullet list specified in Section 5.2.1.

Review Comments for Groundwater Model Report
EPA, Randall R. Ross, Applied Research & Technical Support Branch

General Comments:

The Groundwater Model Report describes the assumptions, input data, results, limitations, and conclusions for a flow and transport model developed for the FMC Plant Operable Unit (OU) of the Eastern Michaud Flats Superfund Site, Pocatello, Idaho. A three-dimensional steady-state flow model was used to simulate transport of the following constituents: arsenic, total phosphorous/orthophosphate, and potassium. Three remedial alternatives were evaluated: Alternative 1 (monitored natural attenuation or MNA) and Alternatives 2 and 3 (source controls, long-term monitoring, hydraulic containment of contaminated groundwater at the Site boundary, and discharge to an on-site percolation basin).

During the development of the groundwater model, FMC held five meetings with EPA, the Idaho Department of Environmental Quality, and the Shoshone-Bannock Tribes. Dr. Beljin and I participated in one of the on-site meetings and had a chance to tour the facility and its vicinity. In general, such meetings are useful for model development, as the conceptual model underlying the numerical model, the model codes, and the model design (e.g., domain, the number of layers, the input parameters, etc.) were agreed upon early on. However, the lack of data for a significant portion of the model domain (i.e., Simplot property) and the limitations of the model were also recognized at the meetings. It was inferred that the model was to be used as an engineering tool to determine the best remedial alternative of the proposed alternatives.

The criteria for the comparison or proposed alternatives are not clearly defined. The only criteria considered were how much the areal extents of the modeled contaminants as defined by the 5 mg/L contours, were reduced after 100 years. The fact that RAOs were not met within 100 years under each of the alternatives appears to have been over-emphasized. The areal extents of the plume compared to the initial plumes should not be the only criteria used in this determination. If a remedial alternative reduces an initial plume by 70 percent over a period of time to a plume with concentrations that are, say, less than 100 mg/L, is that a better alternative than a remedial alternative that reduces the initial plume by 55 percent, but the concentrations are less than, say, 15 mg/L? Obviously, the areal extent is not sufficient to answer the question of which alternative offers a better engineering solution. The total mass of contaminant removed, the rate contaminant removal, the cost of the alternatives, and other factors should be considered.

Because the figures in the Report show simulated plumes based on the highest concentration values from any layer projected onto a single horizontal plane, the information on the vertical distribution of the contaminant is lost. The clean up effort of the alternatives would have different effects on different model layers due to large differences in the hydraulic conductivity distribution (compare Figures 2-5 and 2-6).

During the modeling meetings between the agencies, it was understood that the model in its present form cannot be used to make predictions in terms of concentrations for a specific time frame, given the uncertainties built-in the model assumptions. Unfortunately, the agreed objectives were somehow replaced with the objectives that would require an underlying model that is much more detailed and sophisticated. Many of the input parameters would have to be determined in the field, rather than taken from the literature.

The authors of the Report are correct when describing the model limitations (page 3-11). The model cannot be used as an "absolute predictor of cleanup times"; not for 50 years and definitely not for 100 years. The authors are also correct when they stated that "a more complex set of assumptions for the Simplot site and possible model refinement would be necessary to make EMF Superfund Site cleanup time predictions and to assess impacts to the Portneuf River."

FMC Response: As described in FMC's response to EPA, Bernie Zavala, March 2010, General Comment, FMC agrees that additional site-specific data would be useful to refine the groundwater flow and transport model. However, FMC is concerned that EPA is not acknowledging the significant quantity of site-specific data that has been acquired and was used to develop the groundwater model including data from the Simplot plant site. FMC has made it clear throughout the five (5) model development meetings the FMC groundwater model was not constructed or intended to model contaminant loading, transport or evaluate the performance of Simplot's extraction system within the Simplot Plant OU.

FMC evaluated the residual areal extent of contaminants in groundwater, particularly arsenic exceeding the MCL (ARAR), as the most relevant comparison of the predicted performance of groundwater Alternatives 1, 2 and 3. We believe this is the most relevant measure because regardless of the residual arsenic concentration in groundwater at the site, the groundwater within the area of arsenic above the MCL of 0.01 mg/l meets neither the arsenic ARAR nor the RAO for restoration of groundwater. As MWH described during the May 30, 2010 meeting between FMC, EPA, IDEQ and Tribes to discuss preliminary comments on the SFS, the highest concentrations used to calculate the residual area were essentially all in model layers 1 and 2 (the shallow groundwater zone).

However, as suggested by the comment, the residual mass was calculated based on the sum of the modeled concentration in all four (4) model layers and the performance of groundwater Alternatives 1, 2 and 3 were compared based on the percent reduction in mass for arsenic, total phosphorus / orthophosphate, and potassium in groundwater at the 25, 50 and 100 year time steps. The residual mass was calculated for the FMC Plant Site only (as was the residual areal extent) to minimize effects from the assumptions for the Simplot Plant OU and areas downgradient from both sites toward the Portneuf River. The results of the relative predicted decrease in residual mass are summarized below:

Arsenic:

- After 25 years, Alternative 2 had 1 percent less mass, and Alternative 3 had 9 percent less mass, than Alternative 1.
- After 50 years, Alternative 2 had 1 percent less mass, and Alternative 3 had 13 percent less mass, than Alternative 1.
- After 100 years, Alternative 2 had 2 percent less mass, and Alternative 3 had 18 percent less mass, than Alternative 1.

Total phosphorus / Orthophosphate:

- After 25 years, Alternative 2 had 14 percent less mass, and Alternative 3 had 50 percent less mass, than Alternative 1.
- After 50 years, Alternative 2 had 18 percent less mass, and Alternative 3 had 54 percent less mass, than Alternative 1.
- After 100 years, Alternative 2 had 27 percent less mass, and Alternative 3 had 49 percent less mass, than Alternative 1.

Potassium:

- After 25 years, Alternative 2 had 9 percent less mass, and Alternative 3 had 29 percent less mass, than Alternative 1.
- After 50 years, Alternative 2 had 12 percent less mass, and Alternative 3 had 37 percent less mass, than Alternative 1.
- After 100 years, Alternative 2 had 16 percent less mass, and Alternative 3 had 38 percent less mass, than Alternative 1.

The predicted incremental reduction in the mass of arsenic in groundwater at the FMC Plant Site under Alternatives 2B and 3B show the same lack of significant difference in the predicted reduction in areal extent of arsenic above the MCL when compared to Alternative 1 as shown below:

Groundwater Alternative	Incremental Reduction Arsenic Areal Extent Vs. Alternative 1			Incremental Reduction Arsenic Mass Vs. Alternative 1		
	25 Years	50 Years	100 Years	25 Years	50 Years	100 Years
1	-	-	-	-	-	-
2	1%	0%	2%	1%	1%	2%
3	2%	4%	11%	9%	13%	18%

Sections 3 (Results) and 4 (Conclusions) of the Groundwater Model Report will be revised to include clarification of the areal extent results (area and layers) and a description of the predicted residual mass calculation and results as summarized above in this response. In addition, the SFS Report Sections 7 and 8 will be revised to include a discussion of the predicted residual mass calculation results in parallel with the existing text that describes the results of the predicted residual areal extent for the

groundwater alternatives. However, FMC does not believe that the results and comparison of the predicted residual mass for the groundwater alternatives change the outcome of the screening of groundwater alternatives presented in Section 7 and comparative analysis of groundwater alternatives presented in Section 8 of the SFS Report.

Finally, as stated in FMC's response to the EPA, Bernie Zavala General Comment, FMC agrees to revise the text to qualify the model predictions at the longer-term time steps (beyond 50 years) in the draft SFS Report Sections 7 and 8 and emphasize the model predictions were primarily used to evaluate comparative performance rather than predict the actual performance of a specific alternative over the 100 year model timeframe.

EPA, Randall R. Ross, Applied Research & Technical Support Branch Specific Comments:

1. Figure 1-3. It is not clear how the contours along the Simplot property were determined, especially the contours upgradient from the 4420 contour. For example, the 4450 is next to the shallow well 161 with the water elevation of 4558.74 feet.

   FMC Response: The 4430, 4440 and 4450 contours were not plotted correctly on the source figure (Figure 2.2-1 Groundwater Contour Map Shallow Wells, May 2008 from the Groundwater Current Conditions Report for the FMC Plant OU). Figure 1-3 has been revised to depict only the 4430 and 4440 groundwater contours near shallow wells 164 and 191 and will not infer contours farther to the south (toward shallow well 161). This will make the figure consistent with the typical groundwater contour maps prepared for FMC's annual groundwater monitoring reports.

2. Figure 1-3. The 4392 contour should be closer to monitoring well 515, with the water level of 4392.03 feet. The water level observed in the well 109 is 4388.93, next to the 4385 contour. Please, please provide an explanation for the inconsistencies.

   FMC Response: The 4392 contour was not transferred quite correctly from the source figure (Figure 2.2-1 Groundwater Contour Map Shallow Wells, May 2008 from the Groundwater Current Conditions Report for the FMC Plant OU), and the 4392 contour has been adjusted to its correct position close to Well 515 as suggested by the comment. The 4385 contour is based on the groundwater elevation measured in well 110 (shallow aquifer). Well 109 is a deep well paired with shallow aquifer Well 110 and the groundwater elevation measured in Well 109 reflects the upward vertical gradient from the deep aquifer to the shallow zone. As the figure depicts groundwater contours in the shallow aquifer, Well 109 should not have been posted on the figure and has been removed.

3. Figures 1-4, 1-5, 1-6. The concentration values used to define the concentration contours should be posted (just like the water levels in Figure 1-3).

FMC Response: The figures have been revised as suggested by the comment.

4. Table 2-1. Most likely due to the formatting error, the extraction rate for the well 408 should be -0.2 gpm (not zero). Please, also check the well 403. What is the explanation for such a low extraction rates? Averaging?

   FMC Response: According to Simplot's reports, Well 403 was not pumped in 2008. The average extraction rate for Well 408 should be 0.2 gpm (formatting error) and has been corrected. FMC cannot speculate on the reason for low extraction rates for any of the Simplot extraction wells because FMC is not responsible for the operation of that system.

5. Page 2-16. There is a typo in the following sentence "…the other representing 2015 and 2208 assuming conditions".

   FMC Response: The sentence has been corrected to state "…the other representing 2015 to 2108 assuming conditions…"

6. Page 2-16. Time Discretization. The text explains in detail how the Courant number was used to compute the transport time step length; however, the actual value for the time step is not provided.

   FMC Response: As suggested by the comment, the Groundwater Model Report, page 2-16 has been revised to insert "The time steps for each alternative are all about 4.6 hours."

7. Figure 3-5. How was the observed arsenic plume (dashed outline) drawn? The text indicates that the initial plume was defined by the 0.010 mg/L contour (page 3-8). Why does the contour follow the boundary line? Why are there such large discrepancies between the simulated and observed plumes? What wells were used to draw the observed arsenic plume (2008)? The same comment can be applied to Figures 3-6 and 3-7.

   FMC Response: The observed arsenic plume is based on Figure 5.1-2 from the GWCCR, which is included in Appendix A (Meeting Presentation July 1, 2009) of the Groundwater Model Report. The total phosphorus / orthophosphate and potassium concentration contour maps (GWCCR Figures 5.1-6 and 5.1-3 respectively) are included in Appendix A and were the basis for the observed plume outlines on the Groundwater Model Report Figures 3-6 and 3-7 respectively. Please consult the GWCCR for details on the development (data used) to generate these observed concentration contour maps. We are somewhat unclear on the portion of the comment "Why does the contour follow the boundary line?" As discussed during several meetings, the FMC groundwater model was not developed to model / address the Simplot Plant OU and the concentration contours do not "follow" the property boundary (white dashed line on figures). The concentration contour lines simply do not extend into the Simplot Plant Site. The main discrepancies between the observed

and modeled plumes were discussed during the EPA-FMC model meetings and we believe those are adequately described in the text. For example, with respect to the arsenic plume the Groundwater model Report, Section 3.1.1, second paragraph states:

> "The greatest differences between the model-simulated and observed arsenic plumes in 2008 were in areas adjacent to the Simplot site. In particular, arsenic concentrations were over predicted downgradient of the Simplot former East Overflow Pond (see Well 527). Arsenic concentrations in the southern portion of the joint fenceline area were under predicted compared to observed concentrations that reflect the expansion of the Simplot gypsum stack to the south over the 1994 – 2008 timeframe. This is because 1994 concentrations were used to set constant concentration sources along the Simplot site boundary and maintained at 1994 levels throughout the plume matching period (1994 through 2008)."

No revision to the Groundwater Model Report is necessary to address this comment.

8. The importance of the Simplot data on the overall model results and the impact on the groundwater quality is evident in Figure 3-5. This was also mentioned in the Report "the greatest differences between the model-simulated and observed arsenic plumes in 2008 were in areas adjacent to the Simplot site (page 3-4).

   FMC Response: As stated in FMC's response to the EPA, Randall Ross General Comment, FMC has made clear throughout the five model development meetings that the FMC groundwater model was not constructed or intended to model contaminant loading, transport or evaluate the performance of Simplot's extraction system at the Simplot Plant OU. The predictive simulations were focused on the FMC Plant Site and, therefore, the simplifying assumption regarding Simplot's operations and remedial actions do not significantly affect the utility of the model as a tool to compare groundwater remedial alternatives for the FMC Plant Site. No revision to the Groundwater Model Report is necessary to address this comment.

9. Figure 2-3. The 0.25-125 feet/day hydraulic conductivity zone (blue color) covers most of the model area because of its range. The zone should be refined to better depict the heterogeneity of the zone. A similar comment can be made for Figure 2-5.

   FMC Response: The K range at the low end (0.25-125 feet/day) will be divided into several ranges and Figures 2-3 and 2-5 will be revised to better depict the variability of K in Layers 1 and 3 as suggested by the comment.

10. Figure 2-6. Dr. Beljin and I remain skeptical about the large portion of the model area (Layer 4) having such a high hydraulic conductivity (1,000 to 3,500 feet/day).

    FMC Response: The slug and pump test results summarized on EMF RI Table 3.3-1 (Appendix B of the Groundwater Model Report) include numerous monitoring and production wells completed in the deep groundwater zone (Layer 4) and located spatially throughout the model domain with the exception of the southern elevated

terrain in the Bannock range. Although FMC agrees that the hydraulic conductivities on the table should have been rounded rather than entered at the calculated value to the nearest integer, the slug and pump test results do support the values used in the model. No revision of the Groundwater Model Report is necessary to address this comment.

Review of Quality Assurance Project Plan for Interim CERCLA Groundwater Monitoring for the FMC Site, FMC Idaho, LLC, March, 2010
Donald Matheny, Chemist Environmental Services Unit,

Office of Environmental Assessment
March 11, 2010

I've completed a review of the above QA Project Plan. No significant deficiencies were noted and overall approval is provided. The following comments refer to clarifications or additions and are provided for consideration.

1.0 Project Management - This section should identify the FMC Project Manager and subsequent support contractors by name and include their contact information (e.g., phone, email,..). Is the FMC Project Manager the designated contact point for EPA and will this person be submitting the reports?

> **FMC Response: FMC Response:** FMC understands that EPA guidance recommends that identification of the project organization should include names and contact information and typically this type specific information is provided for projects having finite schedules. However, FMC's experience with its long-term groundwater monitoring programs (now spanning almost 20 years) is that personnel and contracting entities change. For example, FMC's groundwater analytical laboratory has changed five times over the course of the groundwater monitoring program. Rather than creating a QAPP that is virtually guaranteed to need revision simply to update names and contact information, FMC prefers the approach in the QAPP. A new sentence will be added in the QAPP Section 1.1 Project Organization, at the end of the first bullet - FMC Project Manager as follows: "*The FMC Project Manager has overall responsibility for all aspects of the groundwater monitoring program including reporting.*"

1.6 Documentation and Records - What is the retention schedule for all official records related to this data gathering effort?

> **FMC Response:** A new sentence will be added to the end of the paragraph under Section 1.6 Documentation and Records of the QAPP as follows: "*All documentation and records for the Interim CERCLA Groundwater Monitoring Program (ICGMP) will be retained by FMC consistent with the records retention requirements under the Administrative Order on Consent for a Supplemental Remedial Investigation and Supplemental Feasibility Study for the FMC Plant OU, October 2003 and other legal requirements such as those that may be imposed under the RD/RA Consent Decree.*"

2.6 Instrumentation Calibration and Frequency - Recommend running a verification check for field instruments at the end of the day's use in order to verify stability of the sensors or to document possible instrument drift. This would be most applicable to measurement of specific conductance, ORP, turbidity and pH.

FMC Response: Even though not at the end of the day, the daily calibration each morning largely serves the same purpose and are recorded in field logbook. FMC does not believe an additional verification check at the end of each day is needed particularly considering that the field parameter results for the monitoring wells, although valuable for general evaluation of groundwater quality, are not critical data for evaluation in the decision rules. No revision to the ICGMP is necessary to address this comment.

Attachment C – Technical Review of Method 6010B and 6020 – Because method 6020 requires the use of internal standards for analyte quantitation, this section needs to address the review of recoveries for these standards. In addition, the isotopes used as internal standards for the analytes of interest need to be identified and reported by the lab along with the respective recoveries for each sample. In the event that method required dilutions were performed due to poor internal standard performance, these occurrences should also be highlighted in the data verification reports with the affected samples and analytes identified. EPA's most recent Functional Guidelines for Inorganic Data provide a general schema for evaluating internal standards in ICP-MS data that can be used as a general reference here.

FMC Response: Section 2 Technical Review of Methods 6010B and 6020 will be revised in response to the comment. A new bullet will be added to the list under "For Method 6010B and 6020 the following items are evaluated by the DVC" for *ICP-MS Internal Standards* and a new subsection will be added as follows:

ICP-MS INTERNAL STANDARDS:

The DVC will review the results reported for internal standards (IS) and verify that the proper IS were used throughout the analytical sequence and were present in all samples, QC samples, and standards. The DVC will also verify that the % relative intensities (RI) of the IS are in specification, and if out of specification that the proper dilution and reanalysis was employed. If no internal standards were analyzed with the run or an inappropriate IS was utilized the DVC will qualify all affected sample results as unusable (R). If the RI is out of specification or an appropriate dilution was not applied the DVC will qualify all impacted element results as estimated (J).

IDEQ Comments on the Draft SFS Report for the FMC Plant Operable Unit (March 2010) and FMC Reponses

IDEQ General Comments:

1. DEQ appreciates the work that has been accomplished to this point at the FMC OU site, by FMC, its contractors, the Shoshone Bannock Tribes, and EPA.

   FMC Response: FMC appreciates this acknowledgement. No revision to the SFS Report is necessary to address this comment.

2. The ground water flow model (Appendix E) does not include the majority of RA-E on the south end of the site. There should be some text in the document explaining why it was not modeled and how its absence may impact the modeling results.

   FMC Response: The text in Section 2.2, l Domain has been revised as follows:

   The model domain, shown in Figure 2-1, includes the FMC plant site, much of the Simplot plant site, and the northern FMC properties. It extends from the western undeveloped area of the FMC plant site east to the Portneuf River (approximately 15,500 feet), and from the base of the Bannock Range in the south to approximately 4,000 feet north of I-86 (approximately 9,000 feet). The domain covers approximately 2,860 acres. The model domain boundaries were set to encompass the majority of the extensive geologic, hydrogeologic and groundwater quality data for the EMF Site and to minimize boundaries effects within the area of the FMC Plant Site and extending to the major sinks at the Portneuf River (e.g., Batiste Spring).

3. Appendix E: Include ground water modeling results from Alternatives 2A, 2B, 3A, and 3B. It is unclear what results are presented under the Alternative 2 and Alternative 3 headings (with or without the addition of 0.98 cfs and 1.2 cfs of aquifer recharge from the proposed evaporation/infiltration pond in Alternatives 2B and 3B). Also, explain how the recharge was introduced into the model and how it affected ground water flow balance at the site, springs, and proposed pumping rates.

   FMC Response: In Section 2.5.1, the following new paragraph will be added after the first paragraph below the bullet list:

   For Alternatives 2B and 3B, additional recharge was added to the proposed infiltration area upgradient of the plumes at the west end of the FMC Plant Site to simulate infiltration of treated extraction system water. Because the proposed infiltration area was partially outside the model domain, a smaller area was used in the model (approximately 49 acres), and hence a higher recharge value (0.48 in/day for Alternative 2B and 0.64 in/day for Alternative 3B) was assigned to match the volumes of water presented in Appendix C (0.3 in/day over 83 acres for Alternative 2B, and 0.3 in/day over 104 acres for Alternative 3B). This additional

recharge did not make a substantive difference in flow directions or velocities, and impacts to predictive transport simulations were minimal when compared to Alternatives 2A and 3A. Therefore, only results from Alternatives 2B and 3B are presented in Section 3.

IDEQ Specific Comments:

1. **Section 2.4.9, first full paragraph, page 2-27:** Insert "quality" between "groundwater" and "beneath". The text leads the reader to conclude sustained hydraulic head is the cause of ground water contamination. Sustained hydraulic head on source areas did not cause the ground water contamination, rather the movement of surface water containing high concentrations of contaminants into the ground water system from surface water impoundments and/or the leaching of process wastes, such as those listed in this sentence, resulted in groundwater contamination. The removal of contaminated surface water (a primary source) from and the capping of the site's RCRA and Calciner ponds (to reduce/eliminate leaching through the accumulated sediments) have resulted in improved ground water quality.

   FMC Response: Agreed, the text has been revised per the comment as follows:

   Concentrations of FMC-related groundwater impacts in the western ponds area, central plant area and downgradient portions of the joint fenceline / calciner ponds area have decreased (groundwater quality beneath the plant site has improved) and are expected to continue to improve due to discontinued use (i.e., no contaminant solute or mass addition) and lack of sustained hydraulic head to transport constituents through the unsaturated soil column to groundwater at any identified or potential source areas at the FMC Plant OU.

2. **Section 7.1.1, pages 7-2 through 7-6:** The value this section adds to the SFS is unclear. DEQ recommends its removal or rewrite.

   FMC Response: See response to EPA, K. Lynch Specific Comment #5.

3. **Section 7.3.1, second paragraph, second sentence, page 7-1S:** DEQ disagrees with the statement " ...no long-term CERCLA groundwater monitoring... would be performed" as part of the No Action Alternative. If the No Action Alternative was chosen, long-term groundwater monitoring would likely be required to show remedy effectiveness.

   FMC Response: The soil alternatives and groundwater alternatives are described and evaluated in separate subsections of the draft SFS Report. The intent of the “No Action Alternative” is to meet the NCP requirement to evaluate no action for all the contaminated media. Therefore, FMC believes the description of the “No Action Alternative,” including no long-term CERCLA groundwater monitoring (because there would be no CERCLA soil or groundwater remedial action to monitor for effectiveness) is appropriate. The requirements and costs associated with FMC’s

RCRA post-closure and Calciner Ponds post-remedial action groundwater monitoring programs are “free standing” and should not be included within the scope or cost estimates of the SFS. No revision to the SFS Report is necessary to address this comment.

4. **Section 7.3.2.3 Remediation Based Upon Future Site Re-Development:** DEQ struggles with the Receptor Initiated Remediation (RIR) concept. DEQ understands RIR reasoning as an alternative but we do not agree the concept should be considered appropriate as a CERCLA Remedy. DEQ's first concern; is there a documented precedent set for delaying cleanup actions to an undetermined timeframe and remedial action? If this alternative is accepted would there be a finite timeframe established for FMC to complete the action on these RAs? DEQ's concern is that finding a motivated developer to either complete the action or wait for FMC to complete the action may hinder future development and in some cases may result in no action ever completed. DEQ's preference would be that all the work is completed under an approved work plan in a timely manner with FMC completing or overseeing the work to avoid work in the future being completed by unqualified and untrained contractors.

   FMC Response: See response to EPA, K. Lynch General Comment #1.

5. **Section 7.3.3.3 RA-J:** Is the whole RA capped or just a portion occupied by the FMC Trailer.

   FMC Response: Currently, the FMC office trailers are placed within RA-J. Only the small portion (~ 1 acre) where these office trailers (and associated parking area) reside is paved. No revision to the SFS Report is necessary to address this comment.

6. **Section 7.5.2 Groundwater Alternative 1, page 7-51:** Monitored Natural Attenuation (MNA) and Long-Term Groundwater Monitoring (LTM) are not synonymous as it appears to be used in this section. "Natural attenuation is the reduction of contaminants in soil or ground water through natural physical, chemical, or biological processes. The processes degrade or dissipate contaminants and include aerobic and anaerobic biodegradation, dispersion, volatilization, and sorption." (EPA, Office of Research and Development Monitored Natural Attenuation, http ://www.epa.govllandsciencelquickjinderlmna.htm) LTM is usually a component of MNA but it is not all that is required.

   [For the use of MNA] It is necessary to know what specific mechanism (type of sorption or redox reaction) is responsible for the attenuation of inorganics so that the stability of the mechanism can be evaluated. For example, precipitation reactions and absorption into a soil's solid structure (e.g., cesium into specific clay minerals) are generally stable, whereas surface adsorption (e.g., uranium on iron-oxide minerals) and organic partitioning (complexation reactions) are more reversible. Complexation of metals or radionuclides with carrier (chelating) agents (e.g., trivalent chromium with EDTA) may increase their concentrations in water and thus enhance their mobility. Changes in a contaminant's concentration,

> *pH, redox potential, and chemical speciation may reduce a contaminant's stability at a site and release it into the environment. Determining the existence and demonstrating the irreversibility, of these mechanisms is important to show that a MNA remedy is sufficiently protective.*
> *EPA, OSWER Directive 9200A-J7P, April 21, 1999*

Please change MNA to LTM in Alternative 1's title or include further detail on how MNA will be implemented at this site, in accordance with applicable EPA guidance. Have the additional costs, associated with demonstrating MNA, been figured into Alternative I's cost shown in Appendix H?

FMC Response: Please refer to FMC's response to EPA, B. Zavala Specific Comment 5.

7. **Section 7.5.4, second paragraph, item 1), page 7-54:** The MCL for arsenic is 0.01 mg/L or 10 ug/L. Please correct the 10 mg/L text.

   FMC Response: Corrected.

8. **Section 7.5.6, second paragraph, page 7-56:** Please explain why FeCL3 is required as a precipitating agent in order to achieve arsenic removal efficiencies in Alternative 2B, and not Alternative 3B.

   FMC Response: The following explanation will be included in Section 7.5.6:

   > *$FeCl_3$ was chosen as the precipitating reagent in Alternative 2B mainly because of the ratio of arsenic to phosphorus. The lower phosphorus to arsenic ratio in the influent favors treatment using ferric chloride. However, the higher ratio of phosphorus to arsenic in the influent for Alternative 3B favors treatment using lime. Precipitating arsenic and phosphorus with lime would generate a carbonate complex that is very stable and would not require the sludge to be treated as hazardous waste. Ultimately, the most appropriate precipitating reagent will be specified during the remedial design.*

9. **Table 7-6, Groundwater Alternative 3A:** The text in the Groundwater Alternative Description column states the modeling predicts Alternative 2B will reduce the extent of arsenic. Should this be Alternative 3A? Please correct as appropriate. Additionally, model figures (Appendix E) of the predicted arsenic plume do not show the 0.01 mg/L contour.

   FMC Response: The Table has been revised to correct the typographical error identified in this comment. The comment regarding model figures is addressed below in response to IDEQ Specific Comment 10.

10. **Section 9.2, first bullet, page 9-8:** The bullet refers to the 0.01 mg/L arsenic concentration contour as shown in Appendix E figures. Appendix E figures do not show the 0.01 mg/l, concentration contour. Please correct accordingly.

    FMC Response: As we described during the multiple groundwater model meetings, the contour maps from the GWCCR were contoured to the 95th UPL arsenic representative level of 14 µg/l (Michaud 14.1 µg/l) and for consistency so were the figures for the GW Model Report. For the arsenic concentration contours, the 14 µg/l and 10 µg/l contour are essentially coincident (i.e., no monitoring wells used for the contouring have concentrations between 10 µg/l and 14 µg/l). In order to align the text with the figures, the legends for the GW Model Report arsenic contour figures will be revised to indicate a 10 µg/l "cut-off" contour.

11. **Appendix E, Section 1.2.1, top of page 1-9:** The text states 0.1 cm/s is28 ft/day. This is incorrect; 0.1 cm/s is 283 ft/day. Please correct accordingly.

    FMC Response: Agreed, the value was intended to be 280 ft/day (rounded). The text will be revised to the correct value.

12. **Appendix E, Section 1.2.1, second and fourth paragraphs page 1-9:** Conversions of 0.01 cm/s to ft/day are inconsistent. Paragraph 2 - 0.01 cm/s (30 ft/day), Paragraph 4 - 0.01 cm/s(28 ft/day). Please correct accordingly.

    FMC Response: The correct conversion rounded to the nearest integer is 28 ft/day. The value was rounded to 30 ft/day in the second paragraph of Section 1.2.1. The value in the second paragraph of Section 1.2.1 will be revised to 28 ft/day.

13. **Appendix H, Groundwater Alternative Tables 2AIB and 3A1B:** Please explain why proposed production wells for Alternatives 2NB and3NB are 80 ft deep, the proposed new monitoring wells and piezometers are 160 feet deep, and the average depth to the shallow water table at the site is 80 it, based on the SFS.

    FMC Response: The new monitoring wells are proposed for a 160 foot depth based on the expectation that new wells will be required at the "landfill RUs" 16, 17 and 19B/C. The wells in the elevated southern terrain are in the range of 150 to over 200 feet total depth. No wells were estimated for RU 18 as, based on dry hole 138 that was drilled to 168 feet bgs, there is no groundwater in the alluvium/coluvium or bedrock in which to site monitoring wells. The piezometers (3 per extraction well) are based on 80 feet average depth for extraction wells. The sheets for 2A/B and 3A/B will be revised to make this correction; however, the cost estimates presented in the SFS are not affected (rounded to the nearest 100K) by this correction.

14. **Appendix H, Groundwater Alternative Tables 3A and 3D:** Please clarify why 52 new monitoring wells (10 4-inch diameter by 160 feet deep and 42 1-inch diameter by 160 feet deep) are necessary for these alternatives.

FMC Response: Similar to the response to #28, 14 extraction wells are proposed and at 3 piezometers per extraction well equals 42 (80 feet on average) piezometers. Sheets for 3A/B will be revised to make that depth correction. The estimate is based on 10 new monitoring wells at an average depth of 160 feet (same as Alternatives 1 and 2A/B). 10 monitoring wells plus 42 piezometers equals 52 wells.

15. **Appendix G, Section 2.3.1, first paragraph, page 2-4:** See Specific Comment number 1.

    FMC Response: The text has been revised per the comment.

16. **Appendix G, Section 4.2, Field Parameters, second paragraph, page 4-1:** States that data will be statistically tested for trends using methodologies described in Section 4.2. Statistical methods are not provided in this section; please correct accordingly.

    FMC Response: The text has been revised to correct the section referenced to Section 4.3.

17. **Appendix G, Section 4.4.3, Northern perimeter wells, first paragraph page 4-8:** The text states that if northern perimeter wells show an increasing trend, current year data will be compared to the comparative value (CV) to determine whether there is an indication the well is impacted by EMF sources. It is not clear how comparing northern perimeter well data to the CV, which is generally a primary or secondary MCL, will assist in determining impacts from EMF sources. Please provide further clarification.

    FMC Response: The text has been revised to clarify the intent to compare the results to the comparative (background) values on Table 4-1 rather than CVs. The text revision, shown in *italics*, is as follows:

> **<u>Northern perimeter wells</u>**: Any upward trend(s) at well 523, 515, 502, TW-11S, 524 and 525 will first be assessed to determine if the trends are related to undetected results at higher detection limits. If the trends are not related to elevated undetected results, the current year concentrations will be compared to the *representative (background) values (Michaud or Bannock 95th percentile representative values as appropriate based on the hydrogeochemistry at the monitoring well of interest)* per Table 4-1 of the GMP to determine whether there is an indication that the well could be impacted by the EMF Site or other non-EMF source(s). If the result(s) exceed the *representative value(s),* the results will be compared to the concentration and trend(s) observed at the nearest cross-gradient well(s) within the EMF-impacted area to assess whether the changes are EMF related or more likely related to non-EMF sources.

18. **Appendix G, Section 4.4.3, Bullet 3, page 4-8:** DEQ recommends removing Bullet 3 or stating that no action will be taken by FMC.

    FMC Response: The bullet has been moved to the end of the list (moved to bullet 4) and revised to state:

    4. *If the upward trend(s) is likely attributable to Simplot sources, no FMC action is necessary.*

SHOSHONE BANNOCK TRIBES SFS COMMENTS
May 10, 2010

Comments of the Shoshone-Bannock Tribes
Supplemental Feasibility Study Report- March 2010
Eastern Michaud Flats, FMC Plant Operable Unit

GENERAL COMMENT

The Tribes believe that EPA's preferred soil remedy, as presented in the Supplemental Feasibility Study ("SFS") for the site, of capping without treating and/or removing the hazardous waste (in particular elemental phosphorus) in the soil, does not adequately protect the public health, welfare, or environment, in contravention of CERCLA. *See* CERCLA § 104. The selection of capping as the preferred remedy appears to have been a foregone conclusion, and one that was not properly examined. EPA's position on remedial alternatives for the FMC site has largely been influenced by the options chosen through the RCRA Consent Decree. Because capping was the alternative of choice, the Superfund program has had a preconceived idea regarding what degree of cleanup would and should happen. Consequently, the program did not require sufficient effort to be made to determine whether other treatment options might prove superior for the site-specific conditions at FMC.

The Tribes do not concur with EPA's preferred alternative for a groundwater remedy that will at best achieve restoration at the northern property boundary in a 25- to 50-year timeframe and that, further down gradient and closer to the Portneuf River, is not planned to ever achieve restoration of the aquifer. The Tribes are very concerned that EPA is presenting a preferred alternative that in no way can achieve restoration of the groundwater and that EPA is planning to issue a Technical Impracticability waiver during the five-year review process.

Tribal Concerns Regarding Capping

The Tribes have numerous concerns regarding EPA Region X's preferred remedy of capping. First, capping the P4 material appears to promote the generation of new hazardous waste streams, including phosphoric acid and phosphine through uncontrolled reactions. EPA relies on a document drafted by FMC Contractor; Comparison of Conventional and Alternative Capping Systems for Use at the FMC OU, June 2009. Section 3.4.3 Design Consideration for Fate and Transport of Gases states "while phosphine would be expected to react with oxygen in the cap soil to form P205 which would further react with moisture in the soil to form H3P04, the H3P04 would also be expected to react with the alkaline soils to form phosphate compound…. At the very low levels of phosphine expected within the cap soils at the FMC Plant OU, the phosphate compounds would not be expected to build to levels that would change cap chemistry or physical properties; i.e., hydraulic conductivity. There is no data to justify the statement "very low levels of phosphine expected". In fact, data we

at other areas throughout the FMC OU prove otherwise. There is no data to determine whether the soils remain alkaline in nature, what the buffering capacity of the soils are what the redox potentials within the soils are to date, given the volume of phosphorus and the expected conversion of the phosphorus to acid and gas forms.

Comparison of Conventional and Alternative Capping Systems for Use at the FMC OU, June 2009. Section 3.5- Conclusions- Design Consideration for the Fate and Transport of Gasses- Data collected from the capped former RCRA Pond 16S at the FMC Plan Site and studies performed regarding the fate of phosphine gas in soils indicate that the air exchange promoted by the ET covers may be beneficial to PH3 neutralization by allowing continuous oxidation and conversion of phosphine gas that is produced by the wastes into non-toxic by-products.

EPA and FMC are promoting a form of in-situ treatment, neutralization and oxidation, under the guises of capping but with no engineered controls. There are no controls on the rate of reactions, no monitoring to determine what will be the by-products. In-situ Treatment options were screened out during the Preliminary Soil Remediation Technologies screening, in February 2009, with little regard to Tribal comments.

Section 4- REMEDIAL ACTION OBJECTIVES (RAOs)

The National Contingency Plan (NCP) specifies that RAOs be developed to address 1) contaminants of concern, 2) media of concern, 3) potential exposure pathways, and 4) preliminary remediation levels or goals.

The RAOs guide the evaluation and selection of remedial alternatives, including cap placement on various RAs. Performance criteria for remedial options, including capping were developed based on the site-specific RAOs for the FMC Plant OU. Despite the Tribal specific comments regarding an updated RAOs for Phosphorus to include the toxic gas, phosphine, EPA ignored their comments and updated the Remedial Action Objectives for Phosphorus as to prevent direct exposure to elemental phosphorus under conditions that may spontaneously combust, posing a fire hazard, and resultant air emissions that represent a significant risk to human health and the environment.

EPA updated the RAO based on findings of the RI, SRI, SRI Addendum, and other data including groundwater data presented in the GWCCR) collected since the RI, and the findings of the EPA Baseline HHRA and the FMC Supplemental HHRAs. The Human Health Risk Assessment did not evaluate the risks due to inhalation of phosphine gas hydrogen cyanide, any other reaction products of phosphorus or other known by-products of P4. .

The Tribes continuously communicated the need for EPA to evaluate toxic gases throughout the FMC OU in soils, sediments and air, see Tribal comments on the original Record of Decision, 1998, the Supplemental HHRA. FMC's evaluation of P4 in the soils was for the following:

> P4 chronic and sub-chronic hazard quotients are based on a soil concentration of 3000 mg/kg, the estimated maximum soil concentration at which P4 oxidation under cold conditions may potentially occur without the generation of a visually apparent "smoke". At concentrations greater than 3,000 mg/kg incidental ingestion of P4 contaminated soil by workers would be unlikely to occur since they would vacate the area when "smoke" became apparent due to the irritant effect of the acid aerosol which comprises the "smoke". This action would thereby eliminate the potential for long-term worker exposure. An acute hazard could occur if workers were to encounter highly concentrated levels of P4 in the soil column which begins to burn freely. Specifically, combustion of phosphorus generates a visible and irritating acid aerosol and dermal contact could result in third degree thermal burns and secondary toxicity from phosphorus absorbed at the burn would. (Footnote- Table 6-24 HHRA) Summary of Potential Risks to Future Receptors Associated with Exposure to Phossy Water underground Piping

The evaluation cited above may not even reflect conditions within the soil and therefore may not even accurately reflect a reasonable chronic and sub-chronic hazard quotient for soils let alone that needed for phosphine and other gases to accurately reflect the risks associated with P4. It is estimated concentrations of phosphorus in the soils at levels up to 10,000 mg/kg.

The description of the ongoing issues at the RCRA ponds in SFS App. D, § 3.43, also is inaccurate. EPA states that "with the exception of certain instances infrequently observed at isolated locations on Pond 16s, industrial hygiene monitoring at or above the ground surface has not indicated detectable levels of phosphine." EPA acknowledges that "P4 contained in soils may react to form phosphine gas," but then opines that "as phosphine is heavier than air, phosphine gas would be expected to travel horizontally in soils, unless a preferential pathway would allow for upward migration through the soil column. As it travels through the soil, phosphine would be likely reacting with both air in the pore spaces of the soil or soil constituents to convert to P205, phosphoric acid, and phosphate compounds." Instead, due to dangerous levels of phosphine gas buildup, EPA entered into a Time Critical Removal Action at Pond 16s, requiring a Gas Extraction and Treatment System be installed and operated to reduce levels of phosphine. At times phosphine levels were measured in excess of 500,000 ppm. The lower explosive limit for phosphine is 20,000 ppm with an OSHA health risk level set at .3 ppm. Moreover, since December 2009, Pond 15s has been generating levels of phosphine measured as high as 82,000 ppm. It appears that, over time, additional ponds or areas containing P4 may also begin to generate and emit phosphine.

Section 4 APPLICABLE, RELEVANT AND APPROPRIATE REQUIREMENTS

Capping is Inconsistent with the Trust Relationship and with Stated Federal Policies Toward Indian Tribes

> EPA's implementation of CERCLA on the Fort Hall Reservation is informed by the trust relationship that the United States has with Indian Tribes. *E.g.*, *Seminole Nation v. United States*, 316 U.S. 286, 296-97 (1942) (United States has a "moral obligation of the highest responsibility and trust" to Indian tribes and the federal government's "conduct, as disclosed in the acts of those who represent it in dealings

with the Indians, should therefore be judged by the most exacting fiduciary standards"). EPA already must ensure that cleanup of a site within the Tribes' reservation will protect public health, welfare, and environment under CERCLA § 104, and this obligation is heightened by the federal government's trust responsibility to tribes. *See, e.g., Blue Legs v. BIA*, 867 F.2d 1094, 1101 (8th Cir. 1989). There are numerous federal mandates and statements of policy acknowledging this heightened federal responsibility, including in the environmental arena.

For example, in E.O. 13175 (Nov. 6, 2000), 65 Fed. Re. 67249, President Clinton required all federal agencies to have meaningful consultation with Indian tribes, *see* preface and ' 5(a); to take into account the United States' trust relationship with tribes, ' 2(a); and to defer to Indian tribes to establish standards, ' 3(c)(2). President Obama stated his continued commitment to these principles in his Tribal Consultation Memorandum of Nov. 5, 2009, 74 Fed. Reg. 57881, and noted that Afailure to include the voices of tribal officials in formulating policy affecting their communities has all too often led to undesirable and, at times, devastating and tragic results.@ Similarly, the 1984 EPA Indian Policy issued by William Ruckelshaus and reaffirmed by every subsequent EPA Administrator states that "the Agency, in keeping with the federal trust responsibility, will assure that tribal concerns and interests are considered whenever EPA's actions and/or decisions may affect reservation environments." It also states EPA's intent "to give special consideration to Tribal interests in making Agency policy, and to insure the close involvement of Tribal Governments in making decisions and managing environmental programs affecting reservation lands." It recognizes "Tribal governments as the primary parties for setting standards" and "making environmental policy decisions." In addition to the federal trust responsibility, in E.O. 12898 (Feb. 11, 1994), 42 U.S.C. § 4321, President Clinton made achieving environmental justice a part of every federal agency's mission. EPA states on its website that "no group of people . . . should bear a disproportionate share of the negative environmental consequences resulting from industrial . . . operations." http://www.epa.gov/compliance/about/offices/ej.html.

Contrary to these federal mandates and policies, EPA does not appear to be providing meaningful consultation with the Tribes. Tribal comment is not meaningful because EPA has made clear from the beginning that it would not consider treatment or removal as viable alternatives. As early as February 2009, EPA stated that its preferred alternative was capping. EPA also dismissed tribal comments and originally refused to include excavation in the list of alternatives to be evaluated "because it was sure to fall out in the cost." This provided FMC with the understanding that capping would be the preferred alternative. Moreover, choosing capping as the remedy precludes later in-situ treatment of the P4. Since CERCLA prohibits judicial review of the remedy selection until after the remedy is performed, selecting capping as the remedy means that the Tribes' concerns will never be taken into account.

EPA also is not providing deference to tribal standards or tribal policy decisions. The Tribes' position that the hazardous waste should be removed from the Fort Hall

Reservation or at least should be treated has always been clear. Indeed, the Tribes currently are developing Cleanup Standards that contain a requirement to treat ignitable and reactive waste. The Tribes have continued to express concern with capping ignitable and reactive waste, and the RCRA ponds are now reacting to a point that EPA was required to issue a time-critical removal action. As President Obama warned, the failure to include the voices of tribal officials here could lead to undesirable and perhaps even devastating results.

Finally, EPA is not ensuring that everyone, regardless of race, culture, or income, enjoys the same degree of protection from environmental and health hazards,@ *see* EPA website (http://www.epa.gov/compliance/about/offices/ej.html), because it is allowing this hazardous waste to remain untreated on the Fort Hall Reservation, in close proximity to an area of important cultural significance. In fact, EPA's preferred alternative promotes generation of new waste streams. The knowledge that FMC's disposal of P4 and other hazardous waste would have violated the Land Disposal Restrictions had the disposal taken place currently is further evidence that reservation land is not being protected.

Capping Violates Basic Principles of Federal Indian Law

According to principles of federal Indian law, only Congress may extinguish or diminish a reservation. *Solem v. Bartlett*, 465 U.S. 463 (1984); *see also Seymour v. Sup't*, 368 U.S. 351 (1962). As the Supreme Court explained in *Solem*, "only Congress can divest a reservation of its land and diminish its boundaries. Once a block of land is set aside for an Indian Reservation and no matter what happens to the title of individual plots within the area, the entire block retains its reservation status until Congress explicitly indicates otherwise." 465 U.S. at 470.

The capping being recommended here amounts to a diminishment of the reservation. By capping rather than removing or treating the hazardous waste at issue, EPA would essentially be allowing a portion of the reservation to be contaminated in perpetuity, because of the long life of P4 (as well as of the radioactive components in the slag). Capping also will prevent any further development at the site, and so would render this portion of the reservation unusable. Since CERCLA does not contain the explicit language necessary to evidence a Congressional intent to diminish the Fort Hall Reservation, capping of these particular types of hazardous waste on the reservation should not be permissible

SECTION 7- ASSEMBLY AND SCREENING OF REMEDIAL ALTERNATIVES

Section 7.3.6.2

Alternative 6 involves excavation of all P4- contaminated soil/fill, to the extent possible and treatment on-site by caustic hydrolysis. Further evaluation of options including excavation and treatment off-site should be continued. While the costs may be high, this option is feasible given the railroad infrastructure present and FMC's 50

plus years experience with handling phosphorus. The Tribes are in favor of treatment of all P4 material but are not confident all risks have been evaluated. Without this information, superior treatment options and the best scenarios to manage those risks cannot be confidently made. Other treatment options, or a combination of multiple options may be better suited for the site conditions once the generation of phosphine within the soil columns is accurately identified and assessed. Attached to these comments are potential options used at sites to control gases and vapors.

The Tribes also submit that site-specific pilot studies should have been required. No information was made available about the physical, biological, or chemical impacts to soil from generation of phosphine and phosphoric acids. Moreover, no information was presented concerning the effects of the freeze and thaw cycle on P4; whether treatment is a viable option during the winter months; whether there may be changes in soil pH due to uncontrolled reactions; or on the decomposition of metal phosphides. There is conflicting information in the record as to the primary chemical transformation of P4 to phosphine (oxidation and/or hydrolysis or decomposition of metal phosphides),

Section 7.4 Screening of the Assembled Soil Alternatives

Effectiveness-

1. Overall protection of human health and the environment;
2. Reducing the toxicity, mobility, or volume of the contaminated media through the use of treatment that decreases the threats or risks associated with the site contamination; and
3. Short-term (referring to the construction and implementation period) and long-term (referring to long-term permanence of the alternatives) reduction of site risks.

ET caps do not provide overall protection of human health and the environment. This option plans for the oxidation of phosphorus within the soils, hopes for the rate of reaction to generate p205 and finally phosphoric acid or phosphate. This option was generally silent regarding soil moisture properties, as detailed within the SRI description of soil samples- Section 4 SRI. It provides little protection for the soil environment as it will generate new waste streams. These new waste streams, phosphoric acid and phosphine may not meet the Land Disposal Restrictions. Finally, phosphine is listed as an extremely hazardous substance on the CERCLA 302 list. It is unclear if this alternative meets the federal ARARs.

ET will not reduce the toxicity, mobility or volume of contaminated media or decrease the threats or risks associated with the site contamination. It may in fact increase the risks associated with the phosphorus contamination by promoting an environment where the phosphorus will “breath” under the cap, as detailed in Appendix D of the SFS.

ET caps may provide effective for short-term effectiveness but the Tribes do not agree they provide long-term permanence.

Implementability

1. Administrative feasibility; and
2. Technical feasibility of constructing, operating and maintaining a remedial alternative give the particular process options and site –specific conditions.

ET caps are administratively feasible and technically feasible.

Cost- cost estimates during screening stage typically are based on a variety of cost-estimating data, including vendor information, conventional cost estimating guides and previous project totals from similar work. Both O & M and capital costs are developed, and the costs are reduced to a single figure for each alternative, comprising an overall project remediation cost.

FMC's cost estimates for the capping alternatives did not factor in a Gas Extraction System that is likely to be required for this system. The increased cost associated with Operation and Maintenance of this monitoring system must be factored in to give an accurate depiction of costs associated with capping.

7.5 Remedial Alternatives for Groundwater

The Tribes would like to see an amendment to alternative 3 to include full hydraulic control of groundwater at the source areas within the FMC OU. Alternative 3 currently calls for Source controls, institutional controls, long-term monitoring, hydraulic containment of contaminated groundwater at the FMC Plant Site boundary, groundwater extraction at specific source areas, and 1) on-site treatment and discharge to the City of Pocatello POTW or 2) on-site treatment and discharge to an on-site percolation/evaporation basing(s) located in the western undeveloped portion of the FMC Plant Site.

The Groundwater Current Conditions report stated "the most significant factor in the reduction of groundwater constituent concentrations is advective mixing. Mixing of small volumes of EMF affected groundwater with large volumes of unaffected groundwater within the EMF aquifer system substantially reduces the concentration of all constituents, including conservative, non-attenuating solutes such as sulfate, along the groundwater flow path". Dilution is not an acceptable factor to reduce contamination. The Tribes have long commented on their non-concurrence with this method; see Tribal comments to the Record of Decision, 1998.

The Tribes do not support EPA's preferred alternative for a groundwater remedy that will at best achieve restoration at the northern property boundary in a 25- to 50-year timeframe and that, further down gradient and closer to the Portneuf River, is not planned to achieve restoration of the aquifer within a 100-year timeframe. EPA's preferred alternative can in no way achieve restoration and, indeed, EPA contemplates issuing a Technical

Impractibility waiver during the five-year review process. Additional actions may be warranted to achieve restoration within a realistic timeframe.

EPA is proposing an alternative that will generate new waste streams, including phosphine gas and phosphoric acid. Additionally, proposing an alternative based on a hope that, because the P4 in RAs are " currently largely covered with soils or slag, essentially providing a permeable cover through which any gas generation would be migrating and reacting, forming solid phosphates prior to reaching the groundwater," has no site specific data nor scientific merit to support the assumptions. It is unacceptable for EPA to disregard the uncontrolled chemical reactions and migration of toxic gas that have already been demonstrated at this site.

Finally, it seems unlikely that there can be adequate financial assurance to assure maintenance of the cap into what is essentially perpetuity, since P4 has such a long life. CERCLA § 108(b) requires facilities to maintain evidence of financial responsibility "consistent with the degree and duration of risk." Methods of financial assurance in the regulations are not calculated to last for centuries, but only for as long as post-closure care is required, *see* 40 C.F.R. § 265.144(a)(2), which is generally 30 years, 40 C.F.R. § 265.117(a)(1) (unless extended by Regional Administrator, § 265.117(a)(2)(ii)).

As the Tribes have repeatedly commented throughout the SRI/SFS process, EPA continues to be silent on the current and future land uses of the Fort Hall Reservation. The area surrounding the FMC Plant OU is used for industrial, agricultural and residential purposes; it is not isolated, as described. Further, this area is a closed portion of the reservation and encompasses the Fort Hall Bottoms which hold significant cultural, ceremonial, and medicinal value to the Shoshone-Bannock people. Resources and uses of the resources along the Portneuf River corridor have been greatly impacted due to the contamination from the Eastern Michaud Flats Site. We are very disappointed to find the presentation once again is silent on the significance of this area to the Tribes. The description of Power County zoning restrictions and future land use information from the cities of Chubbuck and Pocatello further highlight the absence of any discussion of the Shoshone-Bannock Tribes' land use plans, zoning, and significant uses in this area.

Concerns with Ecological Risks

> EPA believes that marginal exceedances of the no-observed-adverse-effect-level (NOAEL) HQ of one in three parcels and the exceedance of an LOAEL HQ in one parcel can be dismissed because it is EPA's view that community level or population impacts are unlikely. The Tribes do not concur that a community-level and/or population-level effects must occur in order to warrant remedial alternatives. Individual species play an important role in the cultural perspective, however, as well as in the overall health of the environment. Continuing emissions of fluoride are occurring and are expected into the future. The areas at issue are within the boundaries of the Fort Hall Reservation, making the Tribes' views all the more significant, as explained above.

The Tribes again request EPA require risk evaluation from phosphine gas and are confident that, once the exposure scenarios and risk assumptions are communicated, there will be a recommendation that P4 material must be treated. It is estimated that 5,052 to 16, 370 tons of P4 remain within the soils at the FMC site. All of this material may react, generating toxic phosphine gas. We continue to be optimistic that once the 21 railcars within the slag pile will be removed. Reservation land and the people residing on it are unique. There is not an option of simply relocating the population in the event the contamination at issue renders the land unfit for use. The amount of reservation land is finite, and is not exchangeable with non-reservation land, for a variety of reasons (including that reservation land has special legal status). It is noteworthy that the P4 at military reservations was treated, not capped, perhaps for similar reasons.

FMC Response: The following responds to the Tribes' general and specific comments in the order in which they were presented.

A. <u>FMC responses to the Tribes' General Comments</u>

The Tribes' first general comment is their assertion that capping facility wastes, particularly phosphorus-containing wastes, will not adequately protect human health and the environment. FMC has presented extensive information in the SFS Report and in the documents the report cites demonstrating that properly designed caps fully meet this fundamental CERCLA remedial action requirement, and that in contrast, other alternatives such as excavation and treatment present far higher risks, particularly to remediation workers. Capping elemental phosphorus-contaminated fill materials meets the NCP criteria. The Tribes fail to identify any aspect of the NCP criteria under which capping is alleged to be inadequate. Also, capping underwent the same rigorous evaluation process for P4 wastes at the Stauffer Tarpon Springs, Florida NPL site. The selection of ET caps at the FMC site is consistent with EPA's selection of capping at the Stauffer Tarpon Springs site, and the Tribes present no evidence in support of their claims that a departure from those decisions is warranted.

The Tribes also contend that selection of capping as part of the site remedy was a foregone conclusion and that EPA did not properly examine a full range of remedial technologies and alternatives. The record demonstrates otherwise. Capping was one of a wide range of potential remedial alternatives that were assembled early in the SFS remedial alternative screening process. These alternatives were presented in a number of reports, all of which the Tribes received, and were discussed in numerous meetings, all of which the Tribes were invited to and most of which the Tribes attended in person or by conference call. None of those evaluations, meetings, reports, or the alternatives analysis presented in the SFS Report would have been necessary had capping been a foregone conclusion. The Tribes also assert that "*EPA's position on remedial alternatives for the FMC site has largely been influenced by the options chosen through the RCRA Consent Decree*." This is not an accurate statement. Rather, the technology evaluations performed through two rigorous and independent statutory programs have reached the same conclusion, which is that capping is the preferred

alternative over other alternatives that have been examined, including the Tribes' preferred remedy of excavation, treatment, and removal. The Tribes' comments on the SFS Report are very much the same as their comments to the EPA National Remedy Review Board (NRRB) regarding EPA's preliminary review of the proposed remedy for the site and were given due consideration by EPA in that venue. The claim that capping was the preselected alternative is not borne out by the record and impugns the integrity of the process in which the Tribes themselves participated.

The Tribes assert that there has been inadequate evaluation of potential phosphine gas generation at remediation areas (RAs) identified as containing or potentially containing phosphorus. These are the areas for which the SFS Report recommends ET covers. On the contrary, potential phosphine generation has been closely considered both in proposing the capping alternative and in recommending ET caps rather than other types of covers. ET caps allow some air movement through the cover material, minimizing potential phosphine buildup of the kind that can occur under impermeable covers and minimizing the potential need to collect and manage the gas. Phosphine emission levels from the areas proposed for ET covers are expected to be at or close to undetectable levels, thereby ensuring worker safety. The expectation that phosphine levels above the ET cap will be below detection limits is based on the phosphine measurements at these RAs that were made during performance of the SRI field work, which uniformly did not detect any levels of phosphine in the breathing zone of the site workers. This conclusion is also based on the fact that phosphine emissions would not be expected to increase above an ET cap because the underlying P4-containing soils and fill would not be subjected to treatment before cap placement. Notwithstanding these sound reasons for concluding that phosphine levels above or at the perimeter of ET caps will not create a risk to human health or the environment, FMC has proposed to conduct post-remedial action gas monitoring at the ET caps as part of its recommended remedial alternative. FMC would take further action as needed based on this monitoring and EPA direction to assure that the cap meets protectiveness requirements.

The Tribes' arguments that phosphine issues have been overlooked in the development and selection of remedial alternatives has no merit. The potential for phosphine generation has been documented throughout the remedy selection process. Additional data soon will be collected that will quantify phosphine levels on an FMC Plant OU-wide basis, with particular emphasis on the areas that are proposed for ET caps. As directed by EPA, FMC submitted a proposed phosphine investigation work plan to EPA on June 10, 2010. FMC provided copies of this proposed work plan to IDEQ and the Tribes. The phosphine investigation, to be conducted in 2010, will take measurements of phosphine levels in all the areas at the FMC Plant OU that contain or are presumed to contain P4 and thus have a phosphine generation potential. Measurements of phosphine and as warranted other gases will be taken in the shallow fill/soils in P4-containing areas, at the surface of areas with underground piping presumed to contain P4, and in the RCRA ponds areas This will provide additional empirical information that can be used both to demonstrate the absence of any potential worker risk and to provide added support for the recommended CERCLA

remedial action. When the results of this investigation are added to the many years of phosphine monitoring data at the site, there will be ample information to evaluate whether phosphine levels could pose a risk to site workers or the public. The EPA-selected remedial action will take these data and assessment results into account to assure that the remedy meets the fundamental CERCLA requirement of being protective of human health and the environment.

B. FMC Responses to Specific Tribal Comments

1. Section 4—Remedial Action Objectives (RAOs)

In this section of their comments the Tribes assert that the RAOs established for the FMC Plant OU are inadequate because they do not specifically call for preventing risks from potential phosphine inhalation or other exposure. FMC has three responses to this assertion. First, this comment does not specifically address the SFS Report because, while the report applies the RAOs, it does not establish them. Second, RAOs are an administrative tool to guide the development and evaluation of remedial alternatives, not a substitute for meeting the fundamental CERCLA requirement of conducting whatever remedial action may be needed to protect human health and the environment. The CERCLA selected remedy will address the potential risks from all site constituents whether or not they are specifically mentioned in an RAO. Third, the Tribes' comment is factually incorrect. EPA issued FMC a letter dated May 10, 2010 directing FMC to include the following additional RAO in the SFS Report: "Minimize generation and prevent exposure to phosphine and other gases." Further, in the same letter EPA directed FMC to revise the RAO specific to P4 to state as follows: "prevent the direct exposure to elemental phosphorus under conditions that may spontaneously combust, posing a fire hazard or resultant air emissions that represent a significant risk to human health and the environment." The Tribes received a copy of this letter. For all these reasons, the Tribes' challenge to the SFS Report and the overall CERCLA remedial action based on the claim that the RAOs do not address potential risks from phosphine exposure is not only misplaced but also moot.

2. Section 4—Applicable or Relevant and Appropriate Requirements

The Tribes make two comments under this heading. First, they assert that EPA has conducted the CERCLA remedial action process in a manner that violates the United States' trust responsibility to the Tribes. The Tribes claim that EPA has failed to provide "meaningful consultation" with the Tribes during the CERCLA process, in that EPA "made clear from the beginning that it not consider treatment or removal as viable alternatives," and has failed to give "deference to tribal standards or tribal policy decisions."

The argument that EPA has violated the United States' trust responsibility to the Tribes does not relate to the contents of the SFS Report and thus do not call for an FMC response. That comment is directed at EPA and the United States, not FMC. However, FMC has three observations regarding this contention.

First, as discussed in FMC's response to the Tribes' general comments, the record demonstrates that neither EPA nor FMC preselected the capping alternative over other treatment alternatives. Just the opposite—EPA required FMC to evaluate a full range of potential treatment alternatives, and brought into the evaluation process specialists from the U.S. Army Corps of Engineers and the EPA Office of Research and Development to assist in identifying and evaluating P4 treatment and overall management options. The Tribes received copies of all these reports and participated in evaluating them. The record belies the Tribes' claim that capping was preselected and the Tribal consultation process for that reason was not "meaningful."

Second, the Tribes have been fully involved in the SRI/SFS process, as they were during the RI/FS, and they have been provided copies of all the work plans, reports, evaluations and other deliverables that FMC has provided to EPA in this work. To FMC's knowledge the Tribes also have received copies of all the evaluations, directives, correspondence and other materials that EPA has provided to FMC in this project. The Tribes have submitted comments on project deliverables that, like the comments here, have been fully considered and addressed. Further, they have been invited to all the meetings between FMC and the agencies on project deliverables, and have participated in person or by conference call in most of those meetings. It is difficult to imagine how Tribal involvement and participation could have been more complete. This more than meets the federal trust responsibility requirements for consultation with Tribes on matters affecting their interests.

Third, the case law does not support the Tribes' claim that EPA violated the federal trust responsibility by failing to "give deference to tribal standards or tribal policy decisions." The Tribes made a similar argument in attempting to persuade the federal courts not to approve the RCRA consent decree that the United States and FMC had negotiated and ultimately was entered on July 13, 1999 in *United States v. FMC Corporation*, Civil No. CIV-98-0406-E-BLW (USDC Idaho). The Tribes appealed entry of that consent decree to the U.S. Court of Appeals for the Ninth Circuit on grounds that included the argument that EPA had violated the federal trust responsibility by failing to require the RCRA ponds to be excavated and treated rather than closed in place. The Ninth Circuit held as follows:

The Tribes argue that the United States violated its trust duty to the Tribes. We disagree.

We have held that "although the United States does owe a general trust responsibility to Indian tribes, unless there is a specific duty that has been placed on the government with respect to Indians, this responsibility is discharged by the agency's compliance with general regulations and statutes not specifically aimed at protecting Indian tribes." Morongo Band of Mission Indians v. F.A.A., 161 F.3d 569, 574 (9th Cir. 1998).

United States of America v. Shoshone-Bannock Tribes v. FMC Corporation, No. 99-35821, Memorandum Decision, July 7, 2000. CERCLA is not specifically aimed at protecting Indian tribes—it is aimed at protecting overall human health and the environment. Thus EPA discharges its trust responsibility to the Tribes by fully applying CERCLA requirements at the FMC Plant OU to the same extent as it would at any other Superfund site. There is no trust responsibility requirement to "defer" to the Tribes' positions that CERCLA requirements should apply more stringently here or that the Tribes' preferred alternative rises to the level of a Tribal "standard" and "policy."

The Tribes' second comment under this section is that by allowing portions of the FMC Plant OU to be capped, EPA is improperly "extinguishing" or "diminishing" the Fort Hall Reservation. Like the Tribes' contentions that EPA has violated the federal trust responsibility, this comment is directed at EPA and not the SFS Report and does not call for an FMC response. However, FMC observes that these terms have a specific meaning and refer to eliminating reservations or reducing their boundaries. Capping wastes at the FMC Plant OU obviously does not narrow the Fort Hall Reservation boundary, and any argument that capping represents a federal "taking" that amounts to "diminishment" ignores the fact that the FMC Plant OU property is FMC fee-owned property in which the Tribes have no ownership. Although this Tribal argument is aimed at EPA and not FMC, it is plainly specious.

3. <u>Section 7—Assembly and Screening of Remedial Alternatives</u>

a. <u>Section 7.3.6.2</u>

The Tribes make two general comments regarding this section. First, they argue that EPA should select soil Alternative 6, which as described in the SFS Report would consist of excavation of all P4-contaminated soil and fill and on-site treatment using caustic hydrolysis. The factors weighing against soil Alternative 6 are presented in the SFS Report and will not be repeated here.

The Tribes' second general comment is that FMC should have performed "site-specific pilot studies" to confirm that the proposed ET caps would be effective and not have adverse impacts to soil or presumably to the cap itself from "generation of phosphine and phosphoric acids," from the effects of freeze and thaw cycles on P4, from changes in the soil pH due to "uncontrolled reactions," or from "the decomposition of metal phosphides." The Tribes also assert that there is conflicting information in the material FMC has provided as to whether the primary mechanism for conversion of P4 to phosphine is through oxidation, hydrolysis, or decomposition of metal phosphides.

FMC's response is that the SFS Report and the documents it cites provide ample information regarding the inherent reliability and durability of ET caps, because they are made from natural earthen materials, for covering a wide range of contaminated soils including those containing P4. In contrast, the Tribes have not provided any

information demonstrating that any of physical or chemical mechanisms they have listed actually would adversely impact ET caps or result in exposures to phosphine or phosphoric acid that would exceed the CERCLA remedial action requirements for the site. Unfounded speculations cannot overcome the factual information regarding ET cap performance that FMC has provided in the SRI/SFS evaluations and reports. The Tribes' question regarding the different reactions by which P4 or phosphorus compounds can generate phosphine also is a spurious issue. The Tribes have not demonstrated that any conceivable variation in the relative roles of hydrolysis, oxidation, or metal phosphide decomposition would affect the remedy selection or, more to the point, suggest that ET caps would not be protective with respect to potential exposures to phosphine. The phosphine measurement program described earlier in these FMC responses, in which FMC will measure the levels of phosphine and other gases in fill and soils and at the surface of identified P4-containing RAs, will provide added data that will assure that the selected remedy is protective with respect to potential exposures to these gases. FMC also would point out that a number of the unlined historic CERCLA pond areas have been "capped" with earthen fill materials since the late 1950s. Because of the way these areas were "closed and capped," there have not been any identified issues with reactions of P4, including generation of phosphine at levels that were observed or detrimental to site personnel. However, the CERCLA SRI/SFS identified that these historic CERCLA pond areas continue to pose a threat to groundwater from COCs. The ET cap has been determined to be the most appropriate and effective way to address potential groundwater impacts from these units.

b. Section 7.4—Screening of the Assembled Soil Alternatives

The Tribes assert in their comments on Section 7.4 of the SFS Report that ET caps are not protective of human health and the environment. However, again they do not support this assertion with any facts. The SFS Report fully documents the protectiveness of this remedial alternative and that information will not be repeated here. The Tribes also make an incorrect regulatory argument that phosphine and phosphoric acid evolving from P4 reactions in fill and soil would not meet Land Disposal Restriction (LDR) standards. Such standards are inapplicable to these materials. Phosphine at the FMC Plant OU is an uncontained gas that is excluded by the RCRA statute from the category of solid waste, and thus it cannot be a hazardous waste to which LDR requirements could apply. Phosphoric acid that has evolved from P4 waste is not a listed hazardous waste, because it is not a commercial chemical product, manufacturing chemical intermediate or off-specification commercial chemical product under 40 C.F.R. §261.33, and in any event as evolved and present in an environmental medium it would not be generated unless excavated and thus in situ it does not constitute a solid or hazardous waste. LDR requirements therefore similarly do not apply to this material. These inapposite regulatory arguments do not provide any basis for finding that the proposed remedial alternative that includes ET caps is not protective or otherwise does not meet CERCLA requirements.

Lastly, the Tribes argue under this section that FMC's cost estimates for the capping alternatives are deficient because they fail to include the costs for the gas extraction system the Tribes assert will likely be required. In response, FMC does not believe that phosphine will accumulate beneath ET caps to levels that will require gas extraction and treatment—these caps will be earthern and are not expected to trap gas beyond what is occurring under current, i.e, non-capped, conditions. The cost estimates provided in the SFS Report were developed consistent with EPA guidance and are sound. The Tribes have not provided any information supporting their assertion that a gas extraction system likely will be needed at these caps. Thus there is no need to revise the FMC capping cost estimates.

c. Section 7.5—Remedial Alternatives for Groundwater

The Tribes make five comments regarding this section (not including a comment regarding phosphine and phosphoric acid wastes that these FMC responses have addressed previously). First, they state that they would like to see an amendment to groundwater Alternative 3 that would include full hydraulic control of groundwater at the source areas within the FMC Plant OU. FMC's response is that developing such an amendment would not be productive. For the reasons set forth in the SFS Report, full hydraulic control of the source areas is not a viable alternative under the CERCLA criteria of implementability, effectiveness, cost, and other factors.

The Tribes' second comment is that groundwater dilution is not an acceptable means of reducing contamination. This may be the Tribes' position but it is not based on any CERCLA prohibition. Potential impacts to human and ecological receptors, and CERCLA risk-based cleanup requirements, are gauged at the point of exposure and not the point of release. Dilution, attenuation and dispersion factors are inherent in determining the extent to which releases need to be controlled to meet acceptable limits to receptors. The Tribes' position does not reflect CERCLA requirements.

Thirdly, the Tribes disagree with FMC's proposed groundwater alternative because it is not expected to achieve full aquifer restoration within a 100-year timeframe and achieving such restoration may be waived by EPA in the future under a CERCLA technical impracticability waiver. This again is in the nature of Tribal disagreement rather than an objection grounded in CERCLA. The Tribes have not identified any FMC misapplication of the NCP evaluation criteria regarding the groundwater alternatives, nor have they identified any required elements of the CERCLA technical impracticability waiver that they contend FMC would be unable to meet. Furthermore, the Tribes would have the opportunity to comment and consult with EPA regarding any EPA consideration of a technical impracticability waiver.

A fourth Tribal comment regarding this SFS Report section is their assertion that it is unlikely that FMC could provide adequate financial assurance to ensure the long-term ET cap maintenance that would be necessary given the long-term duration of the risks from P4 in the underlying fill and soil. This is another example of the Tribes attempting to undercut the fact-based SFS Report evaluations with speculative

arguments. The Tribes have not brought forward any facts establishing that sufficient long-term financial assurance cannot be secured for the ET caps. This unsupported assertion does not provide any basis for abandoning the ET capping approach that the SFS Report demonstrates fully meets CERCLA requirements and based on the NCP criteria is the preferred alternative.

A final Tribal comment regarding this section is that EPA has ignored Tribal land use plans, Tribal zoning, and the cultural importance to the Tribes of the area near the FMC Plant OU in considering the CERCLA remedy selection. This comment appears to be directed at EPA rather than FMC and does not argue that the SFS Report needs to be changed to reflect these factors. Thus this comment does not appear to call for an FMC response. Nevertheless, FMC observes that the determination that the proposed site remedy is protective of human health and the environment takes into account all current and reasonably anticipated future land uses. Those are based on actual land use patterns, with little reference to local land use and zoning restrictions since those are subject to change. FMC also observes that the fundamental CERCLA remedial action criterion is protection of human health and the environment and that CERCLA does not authorize a higher degree of protection for areas deemed to have cultural significance, or for that matter a lower degree of protection for areas lacking that.

d. Concerns with Ecological Risks

The Tribes make two comments under this heading. First, the Tribes argue that EPA and by implication FMC should assess ecological risks at the FMC Plant OU based on impacts to individual species, rather than focusing on population-level or community-level impacts. The Tribes refer in this context to continuing emissions of fluoride that are claimed to have adverse ecological effects. These Tribal comments relate to the FMC Plant OU Ecological Risk Assessment, not to the SFS Report and thus do not call for an FMC response here. Further, this Tribal comment appears to be related to a different EMF Site OU, specifically the Off-Plant OU, and to ongoing fluoride emissions that, since the FMC plant shutdown, originate entirely from the Simplot facility. These are two additional reasons for concluding that this comment does not relate to the SFS Report and likely does not relate even to the FMC Plant OU.

The Tribes' concluding comment reiterates their concerns regarding the potential for the P4 in the site soils to generate phosphine gas. FMC has addressed this comment earlier in these responses and will not repeat that here.

Attachments to the ShoBan Comments:

- ACCESSING THE CONTENTS OF LARGE BURIAL SITES - Accessing Techniques in Other Countries; and,
- Ballistic Tent-and-Foam System for Vapor Containment

FMC Response: The ShoBan Tribes comments and these attachments attempt to perpetuate their fallacious concept that the elemental phosphorus (P4) in soil and fill materials at specific RAs at the FMC Plant Site can be remediated using technologies used or attempted for the destruction of military ordnance. Ordnance (broadly defined as ammunition, bombs, rockets and [land]mines) are essentially containers of waste material once the military determines the ordnance is obsolete or otherwise seeks to dispose of the ordnance. P4 in soils / fill at the FMC site is not in containers (other than in the buried railcars for which appropriate remedial alternatives were fully evaluated in the SFS) and thus technologies for retrieval and disposal of containerized waste (ordnance) are not applicable to conditions at the FMC Plant Site RAs with identified P4 in soils and fill. At a minimum, any theoretic soil alternative that would include robotic excavation equipment and/or double-tent and foam system would decrease the technical implementability and inflate the already grossly excessive cost associated with Soil Alternatives 5 and 6 which would lead to the same conclusion, e.g., the technology/alternative would be screened out based on the CERCLA evaluation criteria, as currently stated in the SFS Report. No revision to the SFS Report is warranted.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

June 30, 2010

Reply To: ECL-113

CERTIFIED MAIL RETURN RECEIPT REQUESTED

Ms. Barbara Ritchie
FMC Corporation
1735 Market Street
Philadelphia, PA 19103

Re: Eastern Michaud Flats Superfund Site – FMC Plant OU Administrative Order on Consent (AOC) CERCLA 10-2004-0010. EPA response to FMC response to EPA comments on the Supplemental Feasibility Study Report.

Dear Ms. Ritchie:

In an effort to promote transparency in our ongoing discussions regarding completing the FMC OU Supplemental Feasibility Study (SFS) I have prepared the following memo to clarify the EPA's position on several key issues that were documented in EPA's comments on the SFS Report. EPA believes it will be more effective to document these issues that must be considered in moving forward with the completion of the Proposed Plan instead of EPA preparing responses to FMC's responses to EPA comments on the SFS Report. The table below indicates which comments were adequately addressed by FMC and which comments were not adequately addressed regarding the SFS. Additionally, further direction is provided in regards to comments that were not adequately addressed. Hopefully these clarifications will reduce confusion as we work together to complete the FMC OU SFS and the Proposed Plan.

Comments Adequately Addressed	Comments Not Adequately Addressed
EPA, K. Lynch (General Comment 4, 5, 6; Specific Comments 1, 3, 4, 5, 6, 7, 8, 10, 11, 12)	EPA, K. Lynch (General Comments 1, 2, 3; Specific Comments 2, 9)
USACE, M.E. Walsh (Comments 1, 2, 3)	USACE, M.E. Walsh (Comment 2)
EPA, D.J. Reisman (General Comments 1, 2, 3, 4, 5; Specific Comments 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12)	EPA, D.J. Reisman (none)
EPA, S. Rock (General Comments; Specific Comments 5.2.3.1, 5.2.3.3, 6.2.3.1, Soil Cover Cap, 7.3, 8.2, 9.1)	EPA, S. Rock (none)
EPA, B. Zavala (General Comments; Specific Comments 6, 7, 8, 9, 11; Appendix E Comment 2; Appendix G Comment 1, 2, 3, 4, 5; Attachment A Comments 1)	EPA, B. Zavala (Specific Comments 1, 2, 3, 4, 5, 10)
EPA, R. Ross (General Comments; Specific Comments 1, 2, 3, 4, 5, 6, 8, 9, 10)	EPA, R. Ross (Specific Comment 7)
EPA, D. Matheny (Comments adequately addressed)	EPA, D. Matheny (none)

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EPA expects that all comments to be adequately addressed by FMC in the Final SFS. Additional comments on "Comments Not Adequately Addressed" follow.

EPA, K. Lynch response to FMC Response to Comments:
General Comment 1: EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement. In addition, the Overall protection of human health for Alternative 4 should be high.

Additional Comments: "Receptor-initiation remediation" does not adequately protect site visitors, workers, or trespassers from impacted soils and fill materials through inhalation of fugitive dust and gamma radiation exposure. Alternative 2 does not meet the threshold protectiveness requirement and will not be further considered at the FMC OU. However, if prior to the implementation of the Preferred Alternative FMC identifies a developer that is willing to incorporate a remedial action into the development plans for the site, EPA would consider the plan at that time.

General Comment 2: Institutional controls and monitored natural attenuation are not adequate remedial actions for groundwater. ARARs will not be met within a reasonable timeframe. As such, Groundwater Alternative 2 or 3 will be required as part of the selected alternative. Although modeling data currently shows that none of the Groundwater Alternatives will meet RAOs within a reasonable timeframe, site-specific data gathered after the implementation of Groundwater Alternatives 2 or 3 may show that ARARs may be met within a reasonable timeframe. Institutional controls and monitored natural attenuation surely will not meet ARARs.

Additional Comments: Contaminants of concern and phosphorus are migrating outside of the FMC OU. Groundwater Alternative 2 or 3 will be required as part of the selected remedy.

General Comment 3: FMC should revise the text of the SFS to state that COCs in groundwater migrate beyond the FMC and Simplot owned properties discharging into surface waters.

Additional Comments: EPA is concerned that the SFS be accurate. The text should be revised to state that COC's in groundwater migrate beyond the FMC and Simplot owned properties and are discharged to surface water.

Specific Comment 2: Section 5.2.5.3, Thermal Desorption. The report eliminates thermal desorption from further consideration in the screening phase due to excavation, storage, and safety issues during treatment. However, it appears that these same issues would also be present during the implementation of incineration technology which was retained for further consideration. Either thermal desorption should be retained and carried into the final screening of technologies (and potentially the detailed analysis of alternatives) or the differences between the two technologies should be clarified to support the elimination of thermal desorption.

Additional Comments: While EPA does not disagree with FMC's response to the comment, the SFS should be revised to include the rationale presented in the response.

Specific Comment 9: See response to General Comment 3 above.

USACE, M.E. Walsh response to FMC Response to Comments:

Comment 2: Thermal desorption should be carried into the final screening of technologies. Clarifying text to support or eliminate thermal desorption as a remedial alternative should be included in the SFS Report. Language used in FMC's response to the EPA Specific Comment 2 would be appropriate for the SFS Report.

Additional Comments: EPA does not disagree with FMC's response to the comment, the SFS should be revised to include the rationale presented in the response.

EPA, B. Zavala response to FMC Response to Comments:

Specific Comment 1: The second sentence in the second paragraph should be deleted regarding no migration of FMC and Simplot site-related constituents. The next sentence is accurate regarding the groundwater migration.

Additional Comments: EPA still feels that the second sentence is not needed and can confuse the issue. The comment wasn't addressed.

Specific Comment 2: Total phosphorus should be added to the list of COCs for the groundwater technologies. Table 4-3 does have total phosphorus for surface water. Total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water.

Additional Comments: EPA doesn't completely agree with FMC's response. EPA can agree that total phosphorus is not a COC for groundwater but it is for surface water. As mentioned in the comment total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water where it is a COC. Section 5 is the identification of applicable groundwater technologies and the dissolved groundwater with total phosphorus will need treatment. It is recommended that total phosphorus be included on the list for Table 4-3 for groundwater but footnoted on the table that total phosphorus is surface water COC not groundwater but treatment will be needed when groundwater is extracted. EPA's concern is that treatment is needed for total phosphorus when groundwater is extracted and prior to disposal.

Specific Comment 3: Similar to the above comment. Total phosphorus should be added to the list of COCs for the assembly and screening of remedial groundwater alternatives. Table 4-3 does have total phosphorus for surface water. Total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water.

Additional Comments: See the Additional Comments for Specific Comment 2.

Specific Comment 4: Delete bullet #2, existing bullet #4 better describes the migration of impacted groundwater to surface water or into the Off-Plant OU.

Additional Comments: See the Additional Comments for Specific Comment 1.

Specific Comment 5: Alternative 1 must delete "monitored natural attenuation" (MNA) and replace it with long-term-groundwater monitoring. MNA is considered a remedial action methodology and a specific mechanism must be known that either destroys or stabilizes the

COCs. Then the mechanism would be known for the attenuation of the COCs within a reasonable time frame.

Additional Comments: The comment still wasn't completely addressed and EPA feels that this data gap can be address in the Remedial Design. The bullets that were provided in this response should be included in the SFS but the April 1999 OSWER Directive is mainly for Organic compounds. The document that should be referenced for Inorganic Contaminants in Groundwater should be *Monitored Natural Attenuation of Inorganic Contaminants in Groundwater Volume 1 Technical Basis for Assessment*, EPA/600/R-07/139 October 2007. This document provides the framework that is needed for the use of MNA as a remedy for Inorganic Contaminants.

Specific Comment 10: The time frames of greater then 100 years should be viewed with caution because of the input data for the transport modeling not using site specific data.

Additional Comments: See the Additional Comments for Specific Comment 1.

EPA, R. Ross response to FMC Response to Comments:

Additional Comments: Most of the FMC responses to the original comments were adequately addressed, especially with respect to the specific comments. EPA maintains that the FMC groundwater model, due to the lack of site-specific data and the lack of data for the Simplot property, cannot be used as a predictor of cleanup times. EPA acknowledges the FMC effort to acquire site-specific data, particularly for the flow model. However, due to the geochemical complexity of the solute transport processes of arsenic and phosphorous in groundwater, more site-specific data will be needed.

The model is still useful as an engineering tool in evaluating remedial alternatives for the FMC site. Before the best remediation alternative is selected, a set of criteria for comparing the alternatives must be clearly established. The only criterion considered in the report was the size of the plume as defined by a 5-ppm contour. The predicted residual mass results were provided in the response to the comment. Further discussion is needed in the SFS Report to explain the procedure for evaluating the results.

Path Forward

EPA believes that FMC should initiate the preparations of a final version of the SFS Report that will reflect the revisions noted here. FMC must also address comments previously provided from IDEQ, which are included as an enclosure to this letter, in preparing the Final SFS Report. In addition, the Shoshone Bannock Tribes final comments are due to EPA on July 2, 2010 and will be forwarded to FMC when recieved.

We look forward to efficiently and effectively completing the SFS and subsequent Proposed Plan, ROD Amendment and Consent Decree for the FMC OU with a shared vision. If you have any concerns regarding these issues please contact me at (206) 553-2144.

Sincerely,

Kira Lynch
EMF Superfund Project Manager

Enclosure

cc: Doug Tanner, IDEQ-Pocatello
Kelly Wright, Shoshone Bannock Tribes

STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

1410 North Hilton • Boise, Idaho 83706 • (208) 373-0502

C.L. "Butch" Otter, Governor
Toni Hardesty, Director

June 23, 2010

Ms. Kira Lynch, U.S. EPA Region 10
1200 Sixth Avenue, Suite 900
Office of Environmental Cleanup (ECL-113)
Seattle, Washington 98101

Subject: DEQ's Final Comments on the March 2010 FMC OU Draft Supplemental Feasibility Study and FMC's Response to Comments dated June 11, 2010

Dear Ms. Lynch:

The Idaho Department of Environmental Quality (DEQ) has reviewed FMC's Response to Agency Comments on the Draft SFS Report dated June 11, 2010. DEQ generally agrees with FMC's responses to DEQ's comments with the following exceptions:

General Comments:

2. FMC's response to DEQ's General Comment No. 2 does not fully address the comment. RA-E (RU-16) located on the southeastern property boundary contains dried calciner pond solids and is considered a potential threat to ground water. A significant portion of RA-E is outside of the ground water model's domain as presented in the Draft SFS Report, Appendix E. While FMC's response does provide a little more detail on the model domain, it does not specifically address RA-E (RU-16) or its potential impact on the fate and transport of contaminants in the model. DEQ requests additional text be included in Appendix E specifically addressing why a portion of RA-E was not included within the ground water model's domain and the implications to the modeling results.

Specific Comments:

13. DEQ does not agree with the portion of FMC's response to Specific Comment No. 13 that states there is no ground water in bedrock below RU 18, based on a single dry borehole (138) drilled to a depth of 168 feet below ground surface. In the sentence prior to this statement FMC states that wells in the elevated southern terrain are in the range of 150 to over 200 feet in total depth, which implies that depths to ground water are at given locations greater than 200 feet below ground surface and that borehole 138 simply was not drilled deep enough to encounter ground water in the bedrock. However, the remainder of FMC's response to this comment does answer DEQ's concerns so no further response is needed.

Sincerely,

Scott A. Miller, P.G.
Environmental Hydrogeologist

SAM:sjt

C: Doug Tanner, Pocatello Regional Office
COF
Project File copies

Rob Hartman

From: Rob Hartman
Sent: Friday, July 02, 2010 11:39 AM
To: Kira Lynch
Cc: Barbara Ritchie; Marc Bowman
Subject: Preliminary responses and need for clarification to finalize SFS
Attachments: FMC Prelim Response to EPA June 30 2010 letter re add comments on SFS RTC.pdf

Kira: Barbara asked that I forward the attached preliminary responses to your June 30, 2010 letter with comments on FMC's response to comments on the SFS. There are several comments highlighted in yellow that we would appreciate clarification regarding any specific revisions you are seeking. Also, for convenience, preliminary responses in blue highlight indicate the SFS will be further revised and suggests alternate text is provided for your review. Barbara is available today to discuss and then will be on vacation next week. You may contact me next week at your convenience to discuss as well. Thank you, Rob.

Rob J. Hartman
MWH Americas, Inc.
Direct: (801) 617-3256
Fax: (801) 617-4200
Cell: (208) 241-8216
Rob.J.Hartman@mwhglobal.com

Preliminary – For Discussion Only
DRAFT FMC Supplemental Responses

EPA Letter Re: Eastern Michaud Flats Superfund Site - FMC Plant OU Administrative Order on Consent (AOC) CERCLA 10-2004-0010. EPA response to FMC response to EPA comments on the Supplemental Feasibility Study Report, June 30, 2010.

Comments Not Adequately Addressed

EPA, K. Lynch (General Comments 1,2,3; Specific Comments 2, 9)
USACE, M.E. Walsh (Comment 2)
EPA, D.J. Reisman (none)
EPA, S. Rock (none)
EPA, B. Zavala (Specific Comments 1, 2, 3, 4, 5, 10)
EPA, R. Ross (Specific Comment 7)
EPA, D. Matheny (none)

EPA, K. Lynch response to FMC Response to Comments:

General Comment 1: EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement. In addition, the Overall protection of human health for Alternative 4 should be high.

Additional Comments: "Receptor-initiation remediation" does not adequately protect site visitors, workers, or trespassers from impacted soils and fill materials through inhalation of fugitive dust and gamma radiation exposure. Alternative 2 does not meet the threshold protectiveness requirement and will not be further considered at the FMC OU. However, if prior to the implementation of the Preferred Alternative FMC identifies a developer that is willing to incorporate a remedial action into the development plans for the site, EPA would consider the plan at that time.

> **FMC Supplemental Response: What specific revision(s) does EPA believe are needed to address this comment?**

General Comment 2: Institutional controls and monitored natural attenuation are not adequate remedial actions for groundwater. ARARs will not be met within a reasonable timeframe. As such, Groundwater Alternative 2 or 3 will be required as part of the selected alternative. Although modeling data currently shows that none of the Groundwater Alternatives will meet RAOs within a reasonable timeframe, site-specific data gathered after the implementation of Groundwater Alternatives 2 or 3 may show that ARARs may be met within a reasonable timeframe. Institutional controls and monitored natural attenuation surely will not meet ARARs.

Additional Comments: Contaminants of concern and phosphorus are migrating outside of the FMC OU. Groundwater Alternative 2 or 3 will be required as part of the selected remedy.

FMC Supplemental Response: What specific revision(s) does EPA believe are needed to address this comment?

General Comment 3: FMC should revise the text of the SFS to state that COCs in groundwater migrate beyond the FMC and Simplot owned properties discharging into surface waters.

Additional Comments: EPA is concerned that the SFS be accurate. The text should be revised to state that COC's in groundwater migrate beyond the FMC and Simplot owned properties and are discharged to surface water.

FMC Supplemental Response: The text will be revised, the current and suggested alternate text are:

Section 2.4.9 Current Text: "There is no migration of FMC site-related constituents in groundwater beyond FMC- (and Simplot-) owned properties. FMC and Simplot-impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring (aka the Spring at Batiste Road) and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water."

Suggested alternate Section 2.9.4 text: *FMC and Simplot-impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring (aka the Spring at Batiste Road) and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water. However, the areal extent of FMC-impacted groundwater does not extend beyond FMC and Simplot-owned properties and no domestic or public water supply wells are located downgradient of site-impacted groundwater. The Rowland well is the nearest cross-gradient domestic well and is located over 500 feet north of EMF monitoring wells 524 and 525 located at the northern fringe of EMF-impacted groundwater. Collectively, groundwater level / flow direction monitoring, analytical results from water samples from monitoring wells 524 and 525 and analytical results from water samples from the Rowland well over a period spanning from 1990 to 2009 demonstrate the Rowland well is not impacted by EMF-sources and, given its distant cross-gradient location, is highly unlikely to be impacted in the future.*

Specific Comment 2: Section 5.2.5.3, Thermal Desorption. The report eliminates thermal desorption from further consideration in the screening phase due to excavation, storage, and safety issues during treatment. However, it appears that these same issues would also be present during the implementation of incineration technology which was retained for further consideration. Either thermal desorption should be retained and carried into the final screening of technologies (and potentially the detailed analysis of alternatives) or the differences between the two technologies should be clarified to support the elimination of thermal desorption.

Additional Comments: While EPA does not disagree with FMC's response to the comment, the SFS should be revised to include the rationale presented in the response.

FMC Supplemental Response: Agreed.

Specific Comment 9: See response to General Comment 3 above.

USACE, M.E. Walsh response to FMC Response to Comments:

Comment 2: Thermal desorption should be carried into the final screening of technologies. Clarifying text to support or eliminate thermal desorption as a remedial alternative should be included in the SFS Report. Language used in FMC's response to the EPA Specific Comment 2 would be appropriate for the SFS Report.

Additional Comments: EPA does not disagree with FMC's response to the comment, the SFS should be revised to include the rationale presented in the response.

FMC Supplemental Response: Agreed.

EPA, B. Zavala response to FMC Response to Comments:

Specific Comment 1: The second sentence in the second paragraph should be deleted regarding no migration of FMC and Simplot site-related constituents. The next sentence is accurate regarding the groundwater migration.

Additional Comments: EPA still feels that the second sentence is not needed and can confuse the issue. The comment wasn't addressed.

FMC Supplemental Response: The text will be revised, the current and suggested alternate text are as presented in K Lynch General Comment 3 above.

Specific Comment 2: Total phosphorus should be added to the list of COCs for the groundwater technologies. Table 4-3 does have total phosphorus for surface water. Total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water.

Additional Comments: EPA doesn't completely agree with FMC's response. EPA can agree that total phosphorus is not a COC for groundwater but it is for surface water. As mentioned in the comment total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water where it is a COC. Section 5 is the identification of applicable groundwater technologies and the dissolved groundwater with total phosphorus will need treatment. It is recommended that total phosphorus be included on the list for Table 4-3 for groundwater but footnoted on the table that total phosphorus is surface water COC not groundwater but treatment will be

needed when groundwater is extracted. EPA's concern is that treatment is needed for total phosphorus when groundwater is extracted and prior to disposal.

> **FMC Supplemental Response: We appreciate EPA's acknowledgement that total phosphorus is not a groundwater COC for the FMC Plant OU and the SFS already identifies total phosphorus as a surface water COC for the FMC Plant OU. We do not agree with the rationale for including total phosphorus on Table 4-3 or the suggested footnote. The need for and level of treatment of any extracted groundwater is driven by the disposal option NOT the underlying constituents status as a COC. For example, under Groundwater Alternative 2A (extraction and disposal to the POTW), no pre-treatment is needed because the estimated average extracted groundwater meets the City of Pocatello POTW pollutant influent limits (Title 13, Chapter 13.20, and Local Limit 13.20.045) and in fact the average total phosphorus in extracted groundwater (2-3 mg/l) is far less than the current average POTW influent concentration of total phosphorus (about 6-8 mg/l). Similarly, under the "B" disposal options, the selected treatment technology is based on preliminary treatment goals for all constituents (whether COCs or not) prior to discharge to percolation / evaporation basins.**

Specific Comment 3: Similar to the above comment. Total phosphorus should be added to the list of COCs for the assembly and screening of remedial groundwater alternatives. Table 4-3 does have total phosphorus for surface water. Total phosphorus is migrating through the groundwater as a dissolved plume before it discharges into the surface water.

Additional Comments: See the Additional Comments for Specific Comment 2.

> **FMC Supplemental Response: Refer to discussion under Specific Comment 2.**

Specific Comment 4: Delete bullet #2, existing bullet #4 better describes the migration of impacted groundwater to surface water or into the Off-Plant OU.

Additional Comments: See the Additional Comments for Specific Comment 1.

> **FMC Supplemental Response: The text will be revised, the current and suggested alternate text are:**
>
> **Current text (bullets 2-4 as proposed to be revised in June 11, 2010 RTC):**

- There is no migration of FMC site-related constituents in groundwater beyond FMC- (and Simplot-) owned properties, although constituents in groundwater report as surface water to the Portneuf River.

- There are no domestic or public water supply wells located downgradient of site-impacted groundwater. The Rowland well is the nearest cross-gradient domestic well and is located over 500 feet north of EMF

monitoring wells 524 and 525 located at the northern fringe of EMF-impacted groundwater. Collectively, groundwater level / flow direction monitoring, analytical results from water samples from monitoring wells 524 and 525 and analytical results from water samples from the Rowland well over a period spanning from 1990 to 2009 demonstrate the Rowland well is not impacted by EMF-sources and, given its distant cross-gradient location, is highly unlikely to be impacted in the future.

- FMC and Simplot-impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water.

Proposed further revision to bullets:

- ~~*There is no migration of FMC site-related constituents in groundwater beyond FMC- (and Simplot-) owned properties, although constituents in groundwater report as surface water to the Portneuf River.*~~
- *FMC and Simplot-impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water. However, the areal extent of FMC-impacted groundwater does not extend beyond FMC and Simplot-owned properties.*

- *There are no domestic or public water supply wells located downgradient of site-impacted groundwater. The Rowland well is the nearest cross-gradient domestic well and is located over 500 feet north of EMF monitoring wells 524 and 525 located at the northern fringe of EMF-impacted groundwater. Collectively, groundwater level / flow direction monitoring, analytical results from water samples from monitoring wells 524 and 525 and analytical results from water samples from the Rowland well over a period spanning from 1990 to 2009 demonstrate the Rowland well is not impacted by EMF-sources and, given its distant cross-gradient location, is highly unlikely to be impacted in the future.*

Specific Comment 5: Alternative I must delete "monitored natural attenuation" (MNA) and replace it with long-term-groundwater monitoring. MNA is considered a remedial action methodology and a specific mechanism must be known that either destroys or stabilizes the COCs. Then the mechanism would be known for the attenuation of the COCs within a reasonable time frame.

Additional Comments: The comment still wasn't completely addressed and EPA feels that this data gap can be address in the Remedial Design. The bullets that were provided in this response should be included in the SFS but the April 1999 OSWER Directive is mainly for Organic compounds. The document that should be referenced for Inorganic Contaminants in Groundwater should be *Monitored Natural Attenuation of Inorganic Contaminants* in *Groundwater Volume 1 Technical Basis for Assessment, EPN6001R-*

07/139 October 2007. This document provides the framework that is needed for the use of MNA as a remedy for Inorganic Contaminants.

FMC Supplemental Response: Agreed.

Specific Comment 10: The time frames of greater then (sic) 100 years should be viewed with caution because of the input data for the transport modeling not using site specific data.

Additional Comments: See the Additional Comments for Specific Comment 1.

FMC Supplemental Response: Is (Are) there a specific revision(s) EPA believes is needed to address this comment – beyond FMC's June 11, 2010 response: "FMC agrees to revise the text specified in this comment to qualify the model predictions at the longer-term time steps (beyond 50 years). In addition, SFS Report Sections 7 and 8 will be revised to emphasize that the model predictions were primarily used to evaluate comparative performance. These combined revisions will clarify that the 100-year model timeframe was used primarily to compare the performance of groundwater alternatives rather than make specific predictions regarding how long a given alternative would need to operate to achieve a given reduction in the residual areal extent or mass of contamination.**"**

EPA, R. Ross response to FMC Response to Comments:

Additional Comments: Most of the FMC responses to the original comments were adequately addressed, especially with respect to the specific comments. EPA maintains that the FMC groundwater model, due to the lack of site-specific data and the lack of data for the Simplot property, cannot be used as a predictor of cleanup times. EPA acknowledges the FMC effort to acquire site-specific data, particularly for the flow model. However, due to the geochemical complexity of the solute transport processes of arsenic and phosphorous in groundwater, more site-specific data will be needed.
The model is still useful as an engineering tool in evaluating remedial alternatives for the FMC site. Before the best remediation alternative is selected, a set of criteria for comparing the alternatives must be clearly established. The only criterion considered in the report was the size of the plume as defined by a 5-ppm contour. The predicted residual mass results were provided in the response to the comment. Further discussion is needed in the SFS Report to explain the procedure for evaluating the results.

FMC Supplemental Response: The criteria for screening the groundwater alternatives are described in Section 7.6.1. The alternatives are screened against the short and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Screening on the basis of these criteria is specified in the NCP and consistent with Section 4.3 of the *EPA RI/FS Guidance*. Section 8.1 describes the NCP established nine criteria for evaluating remedial action alternatives, and the *EPA RI/FS Guidance* (EPA,

1988)(EPA,1990) that elaborates on these criteria and discusses how they are to be applied. As stated in Section 7.5, the (groundwater) model was developed as a tool to support the detailed evaluation and comparative analysis of groundwater remedial alternatives in this SFS. Is there a specific revision EPA believes is needed to address this comment?

DEQ's Final Comments on the March 2010 FMC OU Draft Supplemental Feasibility Study and FMC's Response to Comments dated June 11, 2010

General Comments:

2. FMC's response to DEQ's General Comment No.2 does not fully address the comment. RA-E (RU-I6) located on the southeastern property boundary contains dried calciner pond solids and is considered a potential threat to groundwater. A significant portion of RA-E is outside of the ground water model's domain as presented in the Draft SFS Report, Appendix E. While FMC's response does provide a little more detail on the model domain, it does not specifically address RA-E (RU-I6) or its potential impact on the fate and transport of contaminants in the model. DEQ requests additional text be included in Appendix E specifically addressing why a portion of RA-E was not included within the ground water model's domain and the implications to the modeling results.

FMC Supplemental Response: The text in Section 2.2. l Domain will be further revised (shown in underline) as follows:

The model domain, shown in Figure 2-1, includes the FMC plant site, much of the Simplot plant site, and the northern FMC properties. It extends from the western undeveloped area of the FMC plant site east to the Portneuf River (approximately 15,500 feet), and from the base of the Bannock Range in the south to approximately 4,000 feet north of I-86 (approximately 9,000 feet). The domain covers approximately 2,860 acres. The model domain boundaries were set to encompass the majority of the extensive geologic, hydrogeologic and groundwater quality data for the EMF Site and to minimize boundaries effects within the area of the FMC Plant Site and extending to the major sinks at the Portneuf River (e.g., Batiste Spring). Due to the relatively sparse hydrogeologic data (e.g., wells) in the far southern portions of the FMC and Simplot plant sites, those areas were not included within the domain. The predictive simulation results are all based on the same initial constituent concentrations measured in wells within the model domain, including wells downgradient from the identified (e.g., southern Simplot gypsum stack and FMC calciner solids storage area) and potential source areas that are located outside the southern model domain boundary. Thus the predictive simulation results are all on a comparable basis with respect to those areas outside the southern domain boundary.

Specific Comments:

13. DEQ does not agree with the portion of FMC's response to Specific Comment No. 13 that states there is no ground water in bedrock below RU 18, based on a single dry borehole (138) drilled to a depth of 168 feet below ground surface. In the sentence prior to this statement FMC states that wells in the elevated southern terrain are in the range of 150 to over 200 feet in total depth, which implies that depths to groundwater are at given locations greater than 200 feet belowground surface and that borehole 138 simply was not drilled deep enough to encounter ground water in the bedrock. However, the

remainder of FMC's response to this comment does answer DEQ's concerns so no further response is needed.

FMC Supplemental Response: Noted.

Rob Hartman

From: Lynch.Kira@epamail.epa.gov
Sent: Thursday, July 08, 2010 10:08 AM
To: Rob Hartman
Cc: Barbara Ritchie; Marc Bowman
Subject: Re: Preliminary responses and need for clarification to finalize SFS

Hi Rob

Sorry it has taken so long for me to get back to you on this. In response to your questions:

1. EPA General Comment 1 - The FS should document that EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement.

2. EPA General Comment 2 - FMC and Simplot impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and , as such, migrates into the Off-Plant OU as surface water. Groundwater contaminated above ARARs must be contained before it mixes with surface water.

3. EPA Specific Comment 10 - Add the following to the FS - Currently, the FMC groundwater model cannot be used as a predictor of site cleanup times due to lack of site-specific data and the lack of data for the Simplot property. Due to the geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater, more site-specific data will be required.

We are fine with all other responses.

Kira Lynch
US EPA Region 10
1200 Sixth Avenue, Suite 900
Office of Environmental Cleanup (ECL-113) Seattle WA 98101
phone: 206-553-2144
cell: 206-850-4323
fax: 206-553-0124

From: Rob Hartman <Rob.J.Hartman@us.mwhglobal.com>

To: Kira Lynch/R10/USEPA/US@EPA

Cc: Barbara Ritchie <Barbara_Ritchie@fmc.com>, Marc Bowman <Marc.E.Bowman@us.mwhglobal.com>

Date: 07/02/2010 10:39 AM

Subject: Preliminary responses and need for clarification to finalize SFS

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Rob J. Hartman
MWH Americas, Inc.
Direct: (801) 617-3256
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Cell: (208) 241-8216
Rob.J.Hartman@mwhglobal.com
[attachment "FMC Prelim Response to EPA June 30 2010 letter re add comments on SFS RTC.pdf" deleted by Kira Lynch/R10/USEPA/US]

Rob Hartman

From: Scott.Miller@deq.idaho.gov
Sent: Monday, July 12, 2010 1:37 PM
To: Rob Hartman
Subject: RE: Proposed additional revision to the GW Model Report in response to DEQ comment

Rob,

The response to General Comment 2 reads much better, is closer to what I was asking for and will satisfy my comment. Thank you

Scott

Scott A. Miller, P.G.
DEQ, State Office
Phone: (208) 373-0328

From: Rob Hartman [mailto:Rob.J.Hartman@us.mwhglobal.com]
Sent: Wednesday, July 07, 2010 8:18 AM
To: Scott Miller
Subject: Proposed additional revision to the GW Model Report in response to DEQ comment

Scott: Kira may have already forwarded FMC's supplemental response to the additional EPA and IDEQ comments on the SFS / GW Model Report to you. We are trying to finalize revisions to the GW Model Report this week, so I am sending the proposed new text responding to IDEQ comment 2 directly to you for review. Let me know if the new text satisfies your comment or if you have some additional suggested text fell free to add to the text below and send back. Call if questions. Thanks, Rob.

Rob J. Hartman, P.G.
MWH Americas, Inc.
Direct: (801) 617-3256
Fax: (801) 617-4200
Cell: (208) 241-8216
Rob.J.Hartman@mwhglobal.com

DEQ's Final Comments on the March 2010 FMC OU Draft Supplemental Feasibility Study and FMC's Response to Comments dated June 11, 2010

General Comments:

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> **FMC Supplemental Response:** The text in Section 2.2. l Domain will be further revised (shown in underline) as follows:

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FMC Supplemental Response: Noted.

Rob Hartman

From: Barbara Ritchie [BARBARA.RITCHIE@fmc.com]
Sent: Thursday, July 15, 2010 3:13 PM
To: Lynch.Kira@epamail.epa.gov
Cc: Rob Hartman
Subject: Re: Preliminary responses and need for clarification to finalize SFS

Kira,

Thank you for follow up email. We are really close, but want to make sure we get it 100% right since we're producing hard copies. Take a look at below and advise if we can talk this afternoon or tomorrow AM. I'm in Pocatello til ~12:30 MDT tomorrow and Rob is on vacation most of next week.

Your Item 1 below -
We need to confirm the scope of the changes to the SFS to address this item. Would suggest that the SFS report be revised to add prominent, bold text in sections 7 and 8 with this statement ("EPA does not agree…") in these sections following the first time the report states otherwise….as opposed to changing the statement and all of the tables where we conclude otherwise.

Your Item 2 below -
Note that in FMC's Preliminary Response the text "*FMC and Simplot impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water*" is from a bullet in Section 2.4.9 and Section 7.5 of the SFS that summarize the GWCCR. This doesn't appear to be the appropriate place to add the suggested sentence stating EPA's position regarding remedy selection (i.e., Groundwater contaminated above ARARs must be contained before it mixes with surface water). As an alternate, we propose to the following text in sections 7 and 8 that connects the groundwater alternative effectiveness evaluation to achievement of the surface water RAO:

"The development, screening and detailed evaluation of groundwater remedial alternatives is primarily focused on their effectiveness achieving the groundwater RAOs but also evaluates their effectiveness in supporting achievement of the surface water RAO. Evaluation of the effectiveness of FMC remedial alternatives in achieving the surface water RAO is complicated due to the comingling of FMC- and Simplot-impacted groundwater prior to discharge to the Portneuf River as surface water."

Your Item 3 below –
In addition to FMC's previously suggested "FMC agrees to revise the text specified in this comment to qualify the model predictions at the longer-term time steps (beyond 50 years). In addition, SFS Report Sections 7 and 8 will be revised to emphasize that the model predictions were primarily used to evaluate comparative performance. These combined revisions will clarify that the 100-year model timeframe was used primarily to compare the performance of groundwater alternatives rather than make specific predictions regarding how long a given alternative would need to operate to achieve a given reduction in the residual areal extent or mass of contamination." We propose the following additional text in Sections 7 and 8:

"Currently, the results of FMC groundwater model predictive simulations for remedial alternatives cannot be used as an absolute predictor of site cleanup times beneath the FMC Plant Site due to the limited site-specific solute transport data. The geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater would require more site-specific data to improve confidence in the model predicted cleanup timeframes. As described in the Groundwater Model Report, the transport model and predictive simulations were not designed to model the Simplot Plant OU or the areas downgradient of the FMC and Simplot Plant Sites where FMC- and Simplot-impacted groundwater comingle and discharge to the Portneuf River as surface water. As such, the model predictive simulations are not and cannot be used to evaluate the comparative or absolute effectiveness of FMC groundwater remedial alternatives in the

areas where FMC- and Simplot-impacted groundwater commingle or for evaluating the effectiveness or timeframe for achieving the surface water RAO."

One last double check –

RAOs – is the prior comment about the 'or' vs. the 'and' in the P4 RAO still relevant now that you've added a PH3 RAO? Would think it's redundant to have the 'or' ?

-----Original Message-----
From: Lynch.Kira@epamail.epa.gov [mailto:Lynch.Kira@epamail.epa.gov]
Sent: Thursday, July 08, 2010 10:08 AM
To: Rob Hartman
Cc: Barbara Ritchie; Marc Bowman
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We are fine with all other responses.

Kira Lynch
US EPA Region 10
1200 Sixth Avenue, Suite 900
Office of Environmental Cleanup (ECL-113)
Seattle WA 98101
phone: 206-553-2144
cell: 206-850-4323
fax: 206-553-0124

From: Rob Hartman <Rob.J.Hartman@us.mwhglobal.com>

To: Kira Lynch/R10/USEPA/US@EPA

Cc: Barbara Ritchie <Barbara_Ritchie@fmc.com>, Marc Bowman <Marc.E.Bowman@us.mwhglobal.com>

Date: 07/02/2010 10:39 AM

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[attachment "FMC Prelim Response to EPA June 30 2010 letter re add comments on SFS RTC.pdf" deleted by Kira Lynch/R10/USEPA/US]

Rob Hartman

From: Lynch.Kira@epamail.epa.gov
Sent: Thursday, July 15, 2010 3:41 PM
To: Barbara Ritchie
Cc: Rob Hartman
Subject: Re: Preliminary responses and need for clarification to finalize SFS

These look fine. Leave the RAO as "or".

Kira Lynch
US EPA Region 10
1200 Sixth Avenue, Suite 900
Office of Environmental Cleanup (ECL-113) Seattle WA 98101
phone: 206-553-2144
cell: 206-850-4323
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From: Barbara Ritchie <BARBARA.RITCHIE@fmc.com>

To: Kira Lynch/R10/USEPA/US@EPA

Cc: Rob Hartman <Rob.J.Hartman@us.mwhglobal.com>

Date: 07/15/2010 02:13 PM

Subject: Re: Preliminary responses and need for clarification to finalize SFS

Kira,

Thank you for follow up email. We are really close, but want to make sure we get it 100% right since we're producing hard copies. Take a look at below and advise if we can talk this afternoon or tomorrow AM.
I'm in Pocatello til ~12:30 MDT tomorrow and Rob is on vacation most of next week.

Your Item 1 below -
We need to confirm the scope of the changes to the SFS to address this item. Would suggest that the SFS report be revised to add prominent, bold text in sections 7 and 8 with this statement ("EPA does not
agree…") in these sections following the first time the report states otherwise….as opposed to changing the statement and all of the tables where we conclude otherwise.

Your Item 2 below -
Note that in FMC's Preliminary Response the text "FMC and Simplot impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and, as such, migrates into the Off-Plant OU as surface water" is from a bullet in Section 2.4.9 and Section 7.5 of the SFS that summarize the GWCCR. This doesn't appear to be the appropriate place to add the suggested sentence stating EPA's position regarding remedy selection (i.e., Groundwater contaminated above ARARs must be contained before it mixes with surface water). As an alternate, we propose to the following

text in sections 7 and 8 that connects the groundwater alternative effectiveness evaluation to achievement of the surface water RAO:

"The development, screening and detailed evaluation of groundwater remedial alternatives is primarily focused on their effectiveness achieving the groundwater RAOs but also evaluates their effectiveness in supporting achievement of the surface water RAO. Evaluation of the effectiveness of FMC remedial alternatives in achieving the surface water RAO is complicated due to the comingling of FMC- and Simplot-impacted groundwater prior to discharge to the Portneuf River as surface water."

Your Item 3 below –
In addition to FMC's previously suggested "FMC agrees to revise the text specified in this comment to qualify the model predictions at the longer-term time steps (beyond 50 years). In addition, SFS Report Sections 7 and 8 will be revised to emphasize that the model predictions were primarily used to evaluate comparative performance. These combined revisions will clarify that the 100-year model timeframe was used primarily to compare the performance of groundwater alternatives rather than make specific predictions regarding how long a given alternative would need to operate to achieve a given reduction in the residual areal extent or mass of contamination." We propose the following additional text in Sections 7 and 8:

"Currently, the results of FMC groundwater model predictive simulations for remedial alternatives cannot be used as an absolute predictor of site cleanup times beneath the FMC Plant Site due to the limited site-specific solute transport data. The geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater would require more site-specific data to improve confidence in the model predicted cleanup timeframes. As described in the Groundwater Model Report, the transport model and predictive simulations were not designed to model the Simplot Plant OU or the areas downgradient of the FMC and Simplot Plant Sites where FMC- and Simplot-impacted groundwater comingle and discharge to the Portneuf River as surface water. As such, the model predictive simulations are not and cannot be used to evaluate the comparative or absolute effectiveness of FMC groundwater remedial alternatives in the areas where FMC- and Simplot-impacted groundwater commingle or for evaluating the effectiveness or timeframe for achieving the surface water RAO."

One last double check –
RAOs – is the prior comment about the 'or' vs. the 'and' in the P4 RAO still relevant now that you've added a PH3 RAO? Would think it's redundant to have the 'or' ?

-----Original Message-----
From: Lynch.Kira@epamail.epa.gov [mailto:Lynch.Kira@epamail.epa.gov]
Sent: Thursday, July 08, 2010 10:08 AM
To: Rob Hartman
Cc: Barbara Ritchie; Marc Bowman
Subject: Re: Preliminary responses and need for clarification to finalize SFS

Hi Rob

Sorry it has taken so long for me to get back to you on this. In response to your questions:

1. EPA General Comment 1 - The FS should document that EPA does not agree that Soil Alternative 2 meets the threshold protectiveness requirement.

2. EPA General Comment 2 - FMC and Simplot impacted groundwater discharges and mixes with the Portneuf River in the area between and including Swanson Road Spring and Batiste Spring and , as such, migrates into the Off-Plant OU as surface water. Groundwater contaminated above ARARs must be contained before it mixes with surface water.

3. EPA Specific Comment 10 - Add the following to the FS - Currently, the FMC groundwater model cannot be used as a predictor of site cleanup times due to lack of site-specific data and the lack of data for the Simplot property. Due to the geochemical complexity of the solute transport processes of arsenic and phosphorus in groundwater, more site-specific data will be required.

We are fine with all other responses.

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From: Rob Hartman <Rob.J.Hartman@us.mwhglobal.com>
To: Kira Lynch/R10/USEPA/US@EPA
Cc: Barbara Ritchie <Barbara_Ritchie@fmc.com>, Marc Bowman <Marc.E.Bowman@us.mwhglobal.com>
Date: 07/02/2010 10:39 AM
Subject: Preliminary responses and need for clarification to finalize SFS

Kira: Barbara asked that I forward the attached preliminary responses to your June 30, 2010 letter with comments on FMC's response to comments on the SFS. There are several comments highlighted in yellow that we would appreciate clarification regarding any specific revisions you are seeking. Also, for convenience, preliminary responses in blue highlight indicate the SFS will be further revised and suggests alternate text is provided for your review. Barbara is available today to discuss and then will be on vacation next week. You may contact me next week at your convenience to discuss as well. Thank you, Rob.

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