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RECORD OF DECISION
For
Groundwater SWMUs 1 through 3
Soil SWMUs 4 through 56

Final

Former Air Force Plant PJKS
Waterton Canyon, Colorado

May 2013

RECORD OF DECISION
FOR
GROUNDWATER SWMUs 1 THROUGH 3
SOIL SWMUs 4 THROUGH 56

FORMER AIR FORCE PLANT PJKS
WATERTON CANYON, COLORADO

FINAL

Prepared for:

United States Air Force Civil Engineer Center
2261 Hughes Avenue, Suite 155
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ACRONYMS AND ABBREVIATIONS

1,2 DCE	1,2-dichloroethene
AMSL	Above Mean Sea Level
AFCEC	Air Force Civil Engineer Center
AFLCMC	Air Force Life Cycle Management Center
AR	Administrative Record
ARAR	Applicable or Relevant and Appropriate Requirement
ASC	Aeronautical Systems Center
bgs	below ground surface
BRA	Baseline Risk Assessment
CBSG	Colorado Basic Standards for Groundwater
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and the Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CMS	Corrective Measures Study
COC	Contaminant of Concern
CSA	Contaminated Soil Area
CSI	Combined Soils Additional Investigation
CSM	Conceptual Site Model
CSSA	Central Support Storage Area
D-1	D-1 Area
D-4	D-4 Fuel Storage Area
DHC	Dehalococcoides Ethenogenes
DNAPL	dense non-aqueous phase liquid
DO	Dissolved Oxygen
DPT	direct-push technology
EE/CA	Engineering Evaluation/Cost Analysis
EEO	Emulsified Edible Oil
EFBC	East Fork Brush Creek
EPA	United States Environmental Protection Agency
EPL	Engineering Propulsion Laboratory
ESD	Explanation of Significant Difference

ACRONYMS AND ABBREVIATIONS (Continued)

FFS	Focused Feasibility Study
ft	feet
ft/day	feet per day
HRC®	Hydrogen Release Compound®
IA/ICM	Interim Action/Interim Corrective Measure
IRP	Installation Restoration Program
LG	Lariat Gulch
LMSSC	Lockheed Martin Space Systems Company
LNAPL	light non-aqueous phase liquid
Lockheed Martin	Lockheed Martin Corporation
LUC	Land Use Control
MCL	Maximum Contaminant Level
MCS	Media Cleanup Standards
µg/L	micrograms per liter
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NDMA	N-Nitrosodimethylamine
O&M	Operation and Maintenance
ORP	Oxidation-Reduction Potential
Order on Consent	State of Colorado Compliance Order on Consent, Number 98-10-08-01
OTL	Ordnance Testing Laboratory
OU	Operable Unit
Parsons	Parsons Engineering Science, Inc.
PCB	Polychlorinated Biphenyl
PJKS	Former USAF Plant PJKS
RAB	Restoration Advisory Board
RACER™	Remedial Action Cost Engineering and Requirements™
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SCA	Systems and Components Area
Shaw	Shaw Environmental, Inc.
SRI	Supplemental RI
SRO	Soil Remediation Objectives
STG	Soil-to-Groundwater Standards

ACRONYMS AND ABBREVIATIONS (Continued)

SWMU	Solid Waste Management Unit
T-8A	T-8A Pumphouse
TCE	Trichloroethylene
TI	Technical Impracticability
USAF	United States Air Force
USC	United States Code
VC	Vinyl Chloride
VOC	Volatile Organic Compound
WFBC	West Fork Brush Creek

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1.0 PART 1: DECLARATION

1.1 SITE NAME AND LOCATION

The former United States Air Force (USAF) Plant, Peter J. Kiewit and Sons (PJKS) Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) Identification Number CO7570090038, is located in Jefferson County, Waterton Canyon, Colorado (**Figure 1**). PJKS, herein, refers to the former USAF Plant, PJKS.

Response actions at PJKS are being concurrently addressed under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Investigation and response actions have been conducted on 56 solid waste management units (SWMUs) identified in the RCRA assessments. Those SWMUs were grouped into six operable units (OUs) for tracking in the CERCLIS database **Table 1**.

1.2 STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedies for the six (6) OUs that encompass 56 SWMUs at PJKS in accordance with CERCLA, as amended by Superfund Act Reauthorization Amendment (SARA) and to the extent practicable, the National Contingency Plan (NCP). The remedies were also selected in accordance with the State of Colorado Compliance Order on Consent (Order on Consent) Number 98-10-08-01 (State of Colorado, 1998), signed on December 29, 1998.

The Order on Consent provides for the integration of RCRA and CERCLA provisions as outlined in the NCP. The Colorado Department of Public Health and Environment (CDPHE) is the lead regulatory agency for PJKS, with oversight by Environmental Protection Agency (EPA). This arrangement was formalized in a March 17, 1999 Memorandum of Understanding between EPA and CDPHE. The Order on Consent provides for a CERCLA ROD to incorporate interim measures (interim actions) on the soils SWMUs with selection of the final remedy for the groundwater SWMUs. Thus, the remedy selected in this ROD is the final remedy for this site that satisfies both regulatory programs. The EPA, CDPHE and the USAF have jointly selected the remedy presented in this ROD. This decision is based on the Administrative Record (AR) for this site.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDIES

PJKS is currently an operating industrial use facility with future land use expected to remain industrial. The overall site management strategy has been to investigate and remediate the SWMUs through interim measures pursuant to the Order on Consent to prevent or minimize disruption to continuing operations. As potential source areas, soil SWMUs were addressed under RCRA first while groundwater SWMUs were investigated. While contaminated soils were found, no materials which would constitute principal threat wastes were identified at the site. Soil SWMUs which would likely need similar remedies because of similar site characteristics were grouped into OUs for EPA tracking purposes (**Table 1**). Considerable soil remediation took place pursuant to the Order on Consent, which adopted an accelerated action approach to the cleanup, equivalent to the removal authority found in CERCLA. This ROD documents the response actions for each of the soil SWMUs, which have already been completed or fully constructed and selects Land Use Controls (LUCs) as an element of the final remedy for the soil SWMUs. This ROD principally selects the final CERCLA remedy described in this ROD for the ground water SWMUs.

Soil SWMUs

Substantial accelerated response actions at the soil SWMUs have already been conducted at PJKS pursuant to the Order on Consent. The RI/FS for the site evaluated the need for additional remedial actions in light of the cleanup activities already performed at the soils SWMUs at PJKS. The 53 soil SWMUs were divided into four (4) OUs, OU-1, 2, 3 and 6. One of three response actions was selected as in Interim Corrective Measure (ICM) at each soil SWMU (**Table 2**). The three types of accelerated actions taken for the soil SWMUs were:

- Closure to unlimited use/unrestricted exposure levels via excavation and proper off-site disposal of contaminated soil;
- Restricted Closure with Land Use Controls (LUCs); or
- Restricted Closure with LUCs and Limited Cover.

Table 3 contains a summary of investigation and remediation (if any) conducted at each SWMU and references to location of the supporting documentation. **Table 4** contains the Remedial Action Objectives (RAOs) for soils where remaining contamination exists, which were based on CDPHE's Tier 2 Soil Remediation Objectives (SRO) values and the associated soil SWMU land use.

The only contaminants of concern (COC) detected above unlimited use/unrestricted exposure levels in the soil SWMUs where polychlorinated biphenyls (PCBs). For those soil SWMUs where unlimited use/unrestricted exposure levels could not be achieved, protection of human health is being achieved by preventing exposure to COC in soil via engineered covers (such as

asphalt or concrete) over the area of contaminated soil and/or the implementation of land use controls.

An additional layer of LUCs for the soil SWMUs will be accomplished through this ROD and implemented through the use of an Notice of Environmental Use Restrictions (Restrictive Notice) implemented pursuant to the Colorado Environmental Covenant Act, Section 25-15-321.5 of the Colorado Hazardous Waste Act, Colorado Revised Statute §§ 25-15-101, *et seq*. ("CHWA"). The PJKS Restrictive Notice will be signed by CDPHE within 90-days of submittal of the PJKS Construction Completion Report, which is a maximum of 180-days from the date the PJKS ROD is signed.

In the interim, all required construction activities associated with the soil SWMUs have been implemented and Lockheed Martin Space Systems Company's (LMSSC), a major operating unit of Lockheed Martin Corporation (Lockheed Martin), active site security program and active presence on the site will ensure that RAOs for the soil SWMUs are achieved until the Restrictive Notice is recorded. In addition, Section V.C.I of the quit claim deed transferring PJKS from the USAF to Lockheed Martin restricts the current and future use of the entire former PJKS property to non-residential.

Because no further remedial construction action is required, this ROD formalizes the requirement for the LUCs and continued operation and maintenance to consider the soil remedies final. The implementation of the operation and maintenance activities for the soil SWMU remedies will be enforced under PJKS Order on Consent and the PJKS Restrictive Notice.

Any determination by the USAF, in consultation with LMSSC, CDPHE and EPA, to pursue unlimited use / unrestricted exposure in the future at restricted soil SWMUs will be documented in a separate decision document, as either an addendum or an Explanation of Significant Differences (ESD) to this ROD.

Groundwater SWMUs

There are three (3) groundwater related SWMUs at PJKS which are divided into 2 OUs; OUs 4 and 5. They are known as the East Fork Brush Creek Groundwater Plume (SWMU 1), the West Fork Brush Creek Groundwater Plume (SWMU 2) (SWMUs 1 and 2 make up OU 5) and the Lariat Gulch Groundwater Plume (SWMU 3) (OU 4). There are two primary COCs associated with the PJKS groundwater SWMUs. Trichlorethylene (TCE), along with the intermediate products formed by the degradation of TCE (a.k.a. daughter products) (from now on TCE and its daughter products will be referred to collectively as TCE), is the principal groundwater COC and causes the most widespread groundwater contaminant plumes on the

site. The second main COC in PJKS groundwater is N-Nitrosodimethylamine (NDMA) that creates groundwater contaminant plumes that are completely within the TCE plume boundaries.

The impacted groundwater in each of the PJKS groundwater SWMUs is classified as "Domestic Use Quality" under the State of Colorado Basic Standards for Groundwater (Section 41.4.A.1.a and 41.4.B.1.a) of 5 Code of Colorado Regulations 1002-41 and has a federal classification as "Class II.A, current source of drinking water". The long-term goal of the selected remedy is to achieve unlimited use/unrestricted exposure levels for NDMA and TCE in all PJKS groundwater wherever it is practicable.

To employ more realistic short-term goals for remediation, both CERCLA and the State of Colorado encourage the use of an initial point of compliance that is initially coincident to the downgradient edge of the plume, or the facility property boundary to identify areas of responsibility for the Air Force actions under RCRA. As a result, per agreement between USAF, EPA and CDPHE, the point of compliance for groundwater is the original PJKS property boundary.

For the two (2) groundwater OUs (i.e., three (3) groundwater SWMUs), the selected remedy for all groundwater contamination plumes at PJKS (**Table 5**) is:

- Alternative 2 from the Focused Feasibility Study (FFS): In-situ Bioremediation with Restrictive Notice.

Based on numerous treatability studies, in-situ anaerobic bioremediation has been shown to be the most effective technology for reducing concentrations of TCE in both bedrock and alluvial groundwater at the Site and may be effective at reducing concentrations of NDMA in the alluvial aquifer. Continued operation of the in-situ bioremediation in both the bedrock and alluvial groundwater TCE contaminant plumes is expected to achieve asymptotic levels or levels required by the Federal Maximum Contaminant Levels (MCLs) and Colorado Basic Standards for Groundwater (CBSG) at the PJKS groundwater point of compliance within an approximately 10-20 year timeframe from the signing of the ROD.

NDMA in the alluvial aquifer is currently expected to achieve the CBSG in a reasonable time frame in alluvial ground water. NDMA responds slowly and inconsistently to bioremediation and the remedy may need re-evaluation during the 5 Year Reviews. In the bedrock ground water, no available technology is expected to bring NDMA levels in the bedrock groundwater down to levels that will meet the CBSGs within a reasonable timeframe. No other technology was determined to be technically practicable from an engineering perspective to treat NDMA in bedrock. Thus, a technical impracticability waiver is being invoked regarding the CBSG standard for NDMA in the bedrock aquifer at PJKS.

Elements of the bioremediation of TCE in PJKS groundwater consist of:

- Injecting a carbon source, such as sodium lactate, emulsified vegetable oil or equivalent, and a bioaugmentation culture, such as Dehalococcoides ethenogenes (DHC) as needed, into the subsurface. Injection will continue to focus on the seven identified bedrock groundwater source areas. Installing additional injection or monitoring wells in other areas of the plume(s) may be conducted as needed to improve the effectiveness of the remedy. Treatment mixtures will be delivered, if necessary, using permanently installed wells or temporary installed injection points. At present, the existing well network is believed sufficient for injection and monitoring. Injection techniques may include "biobarriers", a three dimensional wall of injected materials.
- Monitoring will continue to determine changes within the plume and the effectiveness of the remedy in reducing concentrations of TCE and NDMA. The frequency of treatment is based on evaluation of monitoring data. Other parameters may be monitored in discrete events to evaluate rates and mechanisms of biodegradation.
- LUCs implemented through the Colorado Environmental Covenant Act for the soil SWMUs. The PJKS Restrictive Notice will prohibit future use of groundwater throughout the entire PJKS site property, and ensure that workers performing excavation actions do not come into contact with contaminated groundwater without proper engineering controls.
- NDMA in the alluvial aquifer is currently expected to meet CBSGs but NDMA concentrations in the alluvial groundwater respond slowly and inconsistently. The remedy for NDMA may need to be reviewed during the 5 Year Reviews.
- A TI waiver to the CBSG standard for NDMA is being invoked in this ROD. EPA and CDPHE agreed with the USAF's analysis that neither bioremediation nor any other groundwater treatment technology was technically practicable to reduce the level of NDMA in the contaminated bedrock groundwater to CBSG standards for NDMA within a reasonable time. The approximate lateral extent of the waiver zone is illustrated in **Figure 2**. The vertical extent of the TI Waiver zone is defined as the lower-most bedrock aquifer in which NDMA contamination, exceeding cleanup standards, has been detected. Based on detections in monitoring wells, NDMA contamination in the bedrock aquifer has been detected to a nominal depth of 130 feet below ground surface (bgs).

1.5 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and environment, complies with Federal and State requirements that are applicable or relevant and appropriate (ARAR) (except in the case where an ARAR is waived). The selected remedy is also cost effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. The

remedy also satisfies the statutory preference for treatment as a principal element since in-situ anaerobic bioremediation reduces TCE concentrations in groundwater in bedrock and alluvium and NDMA in the alluvium.

Because this remedy will result in contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is or will be protective of human health and the environment. Such reviews must be performed every five years until such time as a site attains unlimited use/unrestricted exposure levels.

1.6 ROD DATA CERTIFICATION CHECKLIST

The following information is included in *Section 2.0 Part 2: Decision Summary* of this ROD, as indicated below. Additional information can be found in the AR file for this site.

- COCs and their respective concentrations - Section 2.5 Site Characteristics
- Summary of site risks - Section 2.7 Summary of Site Risks
- RAOs and the basis for these levels - Section 2.8 RAOs
- How source materials constituting principal threats will be addressed, not applicable - Section 2.11, Principal Threat Wastes
- Current and reasonably anticipated future land and groundwater use assumptions used in the ROD - Section 2.6 Current and Potential Future Land Use
- Potential land and groundwater use that will be available at the site as a result of the selected final remedy - Section 2.6 Current and Potential Future Land Use
- Estimated capital, annual operation and maintenance (O&M), total present worth costs, discount rate, and the number of years over with the remedy costs estimates are projected - Section 2.10 Summary of Comparative Analysis of Alternatives
- Key factors that led to selecting the final remedy - Section 2.12 Selected Remedy

1.7 AUTHORIZING SIGNATURES

Declared by:

Alex Briskin

10 July 13

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8/7/13

Mr. Martin Hestmark, Assistant Regional Administrator
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Date

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2.0 PART 2: DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The former USAF Plant PJKS, CERCLIS Identification Number CO7570090038, is located in Jefferson County, Waterton Canyon, Colorado **(Figure 1)**. PJKS is a former industrial site located on approximately 464 acres and is completely surrounded by Lockheed Martin's 5,200-acre facility. This former industrial site was closed in 1989.

For the purpose of environmental investigation and remediation, PJKS was divided into six OUs consisting of 56 SWMUs. **Table 1** lists each of the SWMUs located at PJKS and its respective OU. The OUs at PJKS are as follows:

- OU1 consists of all of the soil SWMUs within the Systems and Components Area where rocket fuel was used during tests to determine if various rocket components functioned properly.
- OU2 includes all the soil SWMUs associated with operation of the Engineering Propulsion Laboratory facilities, where engines were tested and new fuels developed and tested.
- OU3 is made up of the test stands and deluge system where rocket engines were test fired and the T8-A containment pond, which collected deluge system liquids.
- OU4 is the Lariat Gulch groundwater plume also known as SWMU 3.
- OU5 is the Brush Creek groundwater plume which includes SWMUs 1 and 2.
- OU6 is the Ordnance-Testing Laboratory, once used for detonation of waste detonators and ordnance.

The USAF is the lead agency for the environmental cleanup at PJKS, which is funded by the Defense Environmental Restoration Account. The PJKS cleanup work is currently performed under a United States Air Force Civil Engineer Center (AFCEC) contract. The Air Force Life Cycle Management Center (AFLCMC) at Wright-Patterson USAF Base, Ohio, manages environmental programs at PJKS. In accordance with the Order on Consent Number 98-10-08-01 (State of Colorado, 1998), the CDPHE is the lead regulator of the cleanup, with EPA oversight.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Site History

Prior to 1956, PJKS and surrounding acreage was used for cattle ranching. In 1957, Lockheed Martin deeded the property to the USAF, which constructed a missile test site. The USAF then contracted Lockheed Martin to operate the plant and be the prime tenant. The USAF used the PJKS facility from 1957 to 1968 as the main test facility for Titan rocket activities, including

rocket assembly, engine testing, and research and development. Fuel development, purification, and testing were also conducted at the site. Test sites and manufacturing including testing buildings were isolated with long distances between structures due to the potential for fire and explosions associated with rocket fuels used and tested. NDMA found at the site is a degradation product of the rocket fuels.

Releases of rocket fuel related contaminants occurred due to intentional and unintentional releases from tanks and structures intended to treat and/or convey waste fuels. Releases of solvents were primarily caused by large scale use of solvents for cleaning of rocket components and test equipment. The actual cause of the widespread PCB contamination in soil SWMUs throughout the former PJKS facility is not clear. Possible sources include erosion of PCB containing gaskets and caulking material used to seal joints in concrete test stands and impoundments or via use of PCB-contaminated oil as a "carrier-oil" for pesticide or herbicide application.

In 1989 environmental investigations began at PJKS and the 56 SWMUs at the facility were divided into six OUs based on similarity of function or site characteristics. In February 2001, the USAF transferred ownership of the property to Lockheed Martin. The USAF, however, has since maintained responsibility for the remediation of PJKS.

Table 3 provides a summary of all of the previous investigations completed at PJKS and describes which of the SWMUs were included in each investigation or activity.

Enforcement Activities

In November 1989, PJKS was added to the National Priorities List as a federal facility. An Order on Consent Number 98-10-08-01 (State of Colorado, 1998) was signed on December 29, 1998. The Order on Consent is an agreement between the USAF and the CDPHE, Hazardous Materials and Waste Management Division that specifies how the USAF was to conduct the investigation of the nature and extent of contamination and conduct remediation of releases to the environment, as needed, at each of the 56 SWMUs. All State and federal corrective action regulations applicable to PJKS, including CERCLA, Defense Environmental Restoration Program, RCRA, NCP, and Colorado Hazardous Waste Act (CHWA), were merged in this agreement. The Order on Consent further provides for the integration of RCRA and CERCLA provisions as outlined in the NCP. The Order on Consent recognizes CDPHE as the lead regulatory agency for PJKS. Any site determination will comply with CERCLA, RCRA and State of Colorado regulations, such as the CHWA.

The USAF as owner, and Lockheed Martin as both operator and now owner, have consistently conducted operations at the former PJKS substantially in compliance with the specific requirements of the Order on Consent and the general requirements of CERCLA, CHWA and

the Colorado Hazardous Waste Regulations. As a result, no other Orders or violations were incurred at PJKS.

2.3 COMMUNITY PARTICIPATION

Public participation activities have been conducted in compliance with the requirements of Section 113(k)(2)(B)(i-iv) of CERCLA/SARA. Public participation in the response action selection process and during the environmental activities at PJKS has been continuously encouraged. In an effort to involve the public in the decision-making process for environmental activities, a Restoration Advisory Board (RAB) for PJKS was established in 1995. The RAB is composed of representatives of CDPHE, EPA, the USAF, LMSSC, and the community. The USAF has held quarterly RAB meetings that were advertised to the public in local newspapers in advance of each meeting. In addition, for each major work plan or report that was submitted to the regulators for review, the USAF issued fact sheets and community mailings summarizing the action. The USAF also periodically conducted community interviews over the years to help identify potential community concerns and encourage participation in the PJKS RAB process. These community interviews also served as the basis for the Community Involvement Plan which was regularly updated and described the Public Outreach Plan for PJKS.

The environmental cleanups were discussed at the RAB meetings. In addition, public comments have been solicited for interim measures or removal actions which contributed to remedial actions at PJKS including:

- SWMUs 11 and 12: Engineering Evaluation and Cost Analysis (EE/CA) OU2 - Upper and Lower Volcano Areas beginning October 25, 2000
- SWMUs 9 and 14: Additional Investigation Report - D-1 Landfill and T-31 Chemical Treatment Facility, Evaluation of Alternatives – D-1 Landfill and T-31 Chemical Treatment Facility, Work Plan – D-1 Landfill Pre-Removal Characterization beginning July 8, 2005
- SWMUs 12, 13, 15, 17, 22, 29, 31: Interim Corrective Measure Study (CMS) – Combined Soils Units beginning July 8, 2005
- SWMUs 1, 2 and 3: Focused EE/CA Groundwater Plumes, Interim Corrective Measure beginning September 28, 2005

The community participation activities conducted specifically to solicit input and comment on the proposed remedies for the groundwater SWMUs as detailed in the *Proposed Plan for Final Groundwater and Soil Remediation at Former Air Force Plant PJKS* (Shaw 2011b) included:

- The USAF placed a formal advertisement in the Columbine Courier on January 11, 2011 and the Denver Post's Your Hub section for Littleton, Lakewood, Englewood,

South Jefferson County and Ken Caryl on January 12, announcing the availability of the Proposed Plan for Groundwater SWMUs.

- A public meeting was held on February 8, 2012 at the Peak, Foothills Park and Recreation District, 6612 South Ward Street Littleton, Colorado to present the preferred alternatives to the public. Comments were requested during the public meeting as well as during the public comment period, which began on January 12, 2012 and ended on February 25, 2012.
- A transcript of the public meeting was made available to the public and placed in the AR. No verbal or written comments were provided at the public meeting.

During the public comment period, no comments were submitted by the EPA or CDPHE nor were there any public comments submitted during the public meeting. However, one written comment was received regarding the long-term water quality impacts to Brush Creek and Chatfield Reservoir. The comment and its response have been included in the Responsiveness Summary located in Appendix A.

The *Focused Feasibility Study (FFS) Report* (Shaw 2010d), *Proposed Plan* (Shaw 2011b), numerous site investigation results reports, treatability study reports, interim remedial action reports and other pertinent documents for PJKS in Waterton Canyon, Colorado were made available to the public and can be found in the AR file located on the internet at:

http://edm-sepublic.documentservices.dla.mil/AESHAdmRec/

Hard copies of the documents can be viewed at the information repository maintained at:

Columbine Branch Library
Reference Desk – Former Air Force Plant PJKS
7706 West Bowles Avenue
Littleton, Colorado

In addition to the Information Repository, project documents including work plans, technical reports, fact sheets, and other materials relating to PJKS investigations can be viewed at the following locations:

EPA Superfund Records Center
1595 Wynkoop Street
Denver, CO 80202-1129
(303) 312-6473 or
1-800-227-8917 x 6473 (Region 8 only)

U.S. Air Force AFLCMC/WNVR Building 8
1801 Tenth Street, Suite 2
Wright Patterson Air Force Base,
Ohio 45433-7626

Colorado Department of Public Health and the Environment (CDPHE)
Hazardous Material and Waste Management
Division Records Center
4300 Cherry Creek Drive South
Denver, CO 80246-1530

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The soil SWMU remedies implemented pursuant to the Order on Consent are consistent with the site management approach and the industrial long term use of the site. The overall site management strategy has been to expedite the investigation and remediation of those soils and groundwater SWMUs known or suspected of having the highest risk to human health or the environment. The use of Interim Actions/Interim Corrective Measures allowed the high priority areas to be quickly addressed without having to delay remediation until a final remedy for the entire site was proposed and approved via a ROD.

PJKS was divided into four OUs (OUs 1-3 and 6) that include all 53 soil SWMUs and two OUs (OUs 4 and 5) that contain the three groundwater SWMUs. The SWMUs were assigned to one of the six OUs based on similarity of function or waste, or site characteristics. For example, OU1 consists of all of the soil SWMUs within the Systems and Components Area where actual rocket fuel was used during tests to determine if various rocket components functioned properly. OU5, the Brush Creek Groundwater Plume is divided into SWMUs 1 and 2 because the groundwater in the OU can flow into one of two different surface water drainages which flow in different directions.

The soil SWMUs where concentrations of soil COCs were present on the ground surface at concentrations higher than worker protection levels were dealt with immediately via excavation and off-site disposal or engineered covers. Primarily, the selection of asphalt or concrete covers as interim measures for soil SWMUs was made to prevent or minimize disruption to continuing operations and/or structural integrity of buildings. Each interim action/interim corrective measure was planned and implemented with the explicit intent of having the interim measure fulfill the requirement of a remedial action for that SWMU. RAOs for soil SWMUs are: (1) where practical, restore soil at the site to unlimited use/unrestricted exposure via excavation, and proper off-site disposal of contaminated soil; or (2) prevent exposure to contaminants through engineering controls (covers), and/or LUCs where PCBs would remain in place. Each proposed interim measure was thoroughly described during RAB meetings, and questions and comments were solicited using a public participation process consistent with both CERCLA

and RCRA Corrective Action requirements. The soil RAOs are being met by the interim actions/interim corrective measures that have been previously implemented. Because this ROD includes the requirement for additional land use controls, Limited Action is the remedy selected for soils in this ROD.

The remedies proposed in this ROD for the groundwater OUs represent the final response action for this site. The impacted groundwater in each of the PJKS groundwater SWMUs is classified as "Domestic Use Quality" by the State of Colorado and has a federal classification of "Class II.A". Based on data from the Fall 2011 groundwater monitoring event, the excess cancer risk for a hypothetical person consuming PJKS groundwater at the maximum concentrations for NDMA and TCE may present a risk greater than the acceptable range in CERCLA, which is from one in one million to one in ten thousand. However, the actual current risks due to groundwater contamination are negligible because there are no pathways for exposure. Exposure is expected to be minimal in this industrial setting. PJKS impacted groundwater is not currently used as a private or public water supply and future use as a water supply will be prohibited via the PJKS Restrictive Notice. As noted above, concentrations of TCE and NDMA in the plumes are greater than state and federal drinking water standards, so a future risk may exist with a change in land use or groundwater use. No principal threat wastes, such as light non-aqueous phase liquids (LNAPLs) or dense non-aqueous phase liquids (DNAPLs), were identified on this site.

Because of the complex geology and mixture of contaminants, there have been numerous phases of investigation and treatability studies or interim measures (interim actions) to ascertain groundwater conditions and evaluate treatment technologies. The results of these studies influenced the corrective measures/feasibility studies in that the studies could focus on the most promising technologies. In addition, these studies demonstrated that there was no practicable technology to meet CBSGs in the bedrock aquifer for NDMA, thus a waiver for this particular ARAR is being invoked in this ROD.

The interim actions performed at the groundwater SWMUs typically began as pilot tests of a particular remedial technology. If the results of the pilot testing showed that a remedial technology was promising, the pilot test was expanded to an interim measure for a larger area. This process allowed proven technologies for treatment of groundwater COCs to be quickly designed and installed.

2.5 SITE CHARACTERISTICS

Surface and Subsurface Features

PJKS is located on the eastern flank of the Front Range. It is situated within an alluvium filled, northwest-trending valley (Central Valley), which is bordered on the west by foothills of the

Rocky Mountains, and on the east by parallel hogback ridges consisting of sedimentary rocks. The facility is divided into two geographic areas; the foothills, which comprise the western two-thirds of the facility, and the Central Valley, which covers the eastern one-third of the facility. The foothills are defined by rugged, irregular mountains of igneous and metamorphic rocks and unnamed tributaries of the East and West Fork of Brush Creek. In the Central Valley, the primary geographic features include the main streams of the East and West Forks of Brush Creek, Lariat Creek and the Engineering Propulsion Laboratory (EPL) ridge. Elevations range from 7,000 feet (ft) above mean sea level (amsl) in the foothills in the western portions of the plant to 5,925 ft amsl in the EFBC drainage near the eastern PJKS boundary (Parsons Engineering Sciences, Inc. [Parsons], 1999).

PJKS surface water is drained by two branches (the East and West Forks) of Brush Creek and by an unnamed tributary to Lariat Creek. East Fork Brush Creek flows southeast off of PJKS, through Lockheed Martin property, and discharges into the South Platte River approximately 1.75 miles downstream from the eastern PJKS boundary. Segments of East Fork Brush Creek are perennial, though the majority of the drainage is ephemeral.

The three geologic units that are associated with groundwater are the alluvium, Fountain Formation, and Precambrian Bedrock. The alluvium is defined as Quaternary age, which is composed of discontinuous layers of unconsolidated clay, sand, silt, gravel, and cobbles. The Fountain Formation makes up the hogback ridges seen at the surface and is composed of sandstone inter-bedded with siltstone and claystone. The Precambrian fractured crystalline rock underlies both the Quaternary age alluvium and Fountain Formation. The distinct geologic units and the groundwater associated with them result in three very different hydrogeological conditions.

Groundwater in the alluvium is characterized by unconfined water table conditions within the saturated zone(s) of that formation. The alluvium is composed of discontinuous layers of unconsolidated clay, sand, silt, gravel, and cobbles and ranges in saturated thickness from 0 to approximately 47 ft. Flow directions in the alluvial aquifer are influenced by surface topography, with groundwater moving from topographic highs to lows and generally from west to east. The topography of the underlying bedrock surface also plays a role in alluvial groundwater flow direction. The measured permeability values for the alluvial aquifer range from 1 to 10 ft per day (ft/day), while the average velocity of the groundwater is 1 ft/day. The potentiometric map of fall 2009 alluvial groundwater elevations are shown in **Figure 3**.

In the Fountain Formation, the inter-bedded sandstone layers can behave as independent aquifers, resulting in an aquifer system rather than one aquifer. Both confined and unconfined conditions are present in the Fountain Formation. The saturated portion of the Fountain Formation is considered part of the lower aquifer system; however, there is no hydraulic

separation from the alluvial aquifer and the underlying Fountain aquifer. Although the two aquifers are hydrologically joined, their hydraulic properties are what separate them. The Fountain Formation at PJKS was formed with relatively flat lying layers of the siltstone and sandstone. At a later point in time, during the uplift of the Rocky Mountains, the Fountain Formation rocks were tilted up at a significant angle with the higher end of the beds to the west. The process of tilting created many fractures within and across the rock layers and some separation along bedding planes. Groundwater flow in the Fountain aquifer is primarily through the many fractures and bedding plane separations. Due to the topography and the tilt of the beds, groundwater flow in the Fountain Formation generally flows towards the east and southeast in parallel surface drainages. In the northern portion of PJKS, the Fountain Formation groundwater flows in the north direction towards Lariat Gulch. Since the hydraulic conductivity varies depending on the lithology of the Fountain aquifer, conductivities can range anywhere from 0.00059 ft/day to 3.53 ft/day, with an average of 0.198 ft/day (Tables 9.3.1.4.3-1, 10.2.5.4.3-1, and 10.3.5.4.3-1, Parsons, 1999). The potentiometric map of fall 2009 Fountain Formation groundwater elevations are shown in **Figure 4**.

Beneath the western two-thirds of the PJKS facility lays the Precambrian aquifer. The aquifer (fractured crystalline rock) underlies both the alluvium and Fountain Formation. Groundwater flow in the Precambrian Formation is characterized as fracture flow. Both confined and unconfined conditions are present. The flow of groundwater is controlled by secondary permeability through joints and fractures. Characterization, fate and transport evaluations are challenging in a fracture flow aquifer. The depth to groundwater ranges anywhere from 7 to 95 ft bgs and the permeability rates are from 0.0136 ft/day to 4.83 ft/day with an average of 0.687 ft/day (Parsons, 1999). Conductivities can range anywhere from 0.04165 ft/day to 4.826 ft/day (Tables 10.2.5.4.3-1 and 10.3.5.4.3-1, Parsons, 1999), depending on the geographic location. The potentiometric map of fall 2009 Precambrian bedrock groundwater elevations are shown on **Figure 5**.

Depending on the stratigraphic relationship of these hydrogeologic units at any specific location within PJKS, groundwater flows between one or more of these units.

Cultural Resources

Four archaeological sites unrelated to industrial activities were identified during a literature search at the Colorado Historical Society. Additional sites were not identified during three subsequent surveys of the areas. Buildings associated with missile and heavy space launch vehicle development and testing were deemed eligible for listing on the National Register of Historic Places. As part of a Memorandum of Agreement between the USAF, State Historic Preservation Office, and the Advisory Council on Historic Preservation, extensive documentation of these buildings was completed prior to their removal (Earth Tech, 1996). No

cultural resources at PJKS have been impacted by contamination at any of the SWMUs, nor is it expected during ongoing activities.

Conceptual Site Model

Numerous studies of PJKS groundwater composition and fate and transport of contaminants have contributed to development of a conceptual site model (CSM) of conditions at PJKS. The CSM, which is graphically illustrated in **Figures 6 and 7**, is a summary of site conditions that identifies: the type and location of sources of contamination; and how and where people, plants or animals may be exposed to the contamination.

On-site surface water is drained by two branches (the East and West Forks) of Brush Creek and by an unnamed tributary to Lariat Creek. Both forks of Brush Creek flow southeast off of the PJKS property, through Lockheed Martin property, reconnect and discharge into the South Platte River approximately 1.75 miles downstream from the eastern PJKS boundary. Segments of both forks of Brush Creek are perennial, though the majority of the east fork drainage is ephemeral. Flows in the ephemeral Lariat Creek generally dissipate through percolation into sandy soils upstream from Chatfield Reservoir, which is located 2.5 miles northeast of the northeastern corner of the facility property. The alluvium of the South Platte River is also considered a drinking water source. Given the relationship between the alluvial groundwater and bedrock aquifer, all COCs in the alluvial groundwater system are influenced by the bedrock aquifer. The South Platte River flows into Chatfield Reservoir, which is used for flood control, recreation, and as a reserve water supply for the City and County of Denver. The city of Englewood has an intake for its drinking water supply on the South Platte River approximately 3 miles downstream from Chatfield Reservoir (Parsons, 1998).

As shown in **Figure 8**, contaminated groundwater does discharge to surface water in some locations within PJKS. However, due to the volatile nature of TCE and its daughter products, most of the TCE evaporates as it emerges at the ground surface. The remaining TCE, if any, is diluted by the surface water flow such that TCE is not detected in PJKS surface water. The NDMA, while being difficult to treat underground, breaks down chemically very quickly in sunlight due to ultraviolet radiation. Because of the chemical break down caused by exposure to sunlight and the dilution that occurs in the streams, NDMA is also not detected in PJKS surface water.

Overview of Groundwater OUs

Groundwater contamination at PJKS has resulted from activities associated with the development of rocket launch equipment, engine testing, and/or fuels development, purification, and testing. Groundwater monitoring data has identified two primary COCs; TCE (the primary COC) and NDMA (less dispersed than TCE). Several decades of groundwater

quality monitoring at PJKS are available to demonstrate that the PJKS groundwater contaminant plumes have not changed in size or shape for at least ten- (10-) years and are not continuing to migrate further down gradient.

There are seven source areas contributing to three groundwater plumes, which are identified in **Figure 8**. Generally, the plumes appear to originate near specific operational locations within PJKS. These seven plume areas are considered the sole bedrock sources of groundwater contamination at PJKS.

Sources of PJKS contamination were developed from distribution maps of TCE, which were plotted in each of the three groundwater aquifers (the alluvial, Fountain, and Precambrian).

The three groundwater SWMUs at PJKS include:

- SWMU 1 East Fork Brush Creek Groundwater Plume
- SWMU 2 West Fork Brush Creek Groundwater Plume
- SWMU 3 Lariat Gulch Groundwater Plume

SWMU 1 – East Fork Brush Creek (EFBC) Groundwater Plume is located in the central eastern portion of PJKS, extending from the center of the site east and southeast. Current and historical data indicate that TCE and NDMA contamination in the EFBC SWMU originates from the D-1 area (D-1), D-4 Fuel Storage Area (D-4), EPL, Systems and Components General Area (SCA), Central Support Storage Area (CSSA), and Pumphouse (T-8A) source areas. The TCE and NDMA contamination has migrated approximately 1,200 feet (ft) southeast of the PJKS boundary in the alluvium. Groundwater monitoring data from the alluvial well (5-M04), considered to be the furthest downgradient monitoring well to have been impacted by PJKS-sourced contamination, indicates that TCE and NDMA concentrations have remained stable and within a narrow range from slightly above to slightly below the CBSGs since 2004.

SWMU 2 – West Fork Brush Creek (WFBC) Groundwater Plume is located in the southeastern portion of PJKS. Current and historical data indicate that TCE contamination in the West Fork Brush Creek SWMU originates from the D-1, T-8A, and Ordnance Testing Laboratory (OTL) source areas. The NDMA contamination in the SWMU originates from the D-1 and T-8A source areas. The TCE contamination has migrated approximately 900 ft southeast of the PJKS boundary in the alluvium. Data indicate the TCE in the WFBC SWMU is not migrating further down gradient from the source areas. Data also indicate that the NDMA plume in the WFBC is stable, and NDMA contamination in the WFBC is not migrating further down gradient from the source areas.

SWMU 3 – Lariat Gulch (LG) Groundwater Plume is located in the northeast section of PJKS. Current and historical data indicate that TCE contamination in the LG SWMU

originates from the D-4, EPL, SCA, and CSSA source areas. Data indicate that NDMA contamination in the LG SWMU originates from the SCA and CSSA source areas. Both TCE and NDMA contamination have migrated beyond the PJKS boundary in the alluvium. The TCE has migrated approximately 1,300 ft north and NDMA approximately 300 ft north. Historical data over at least the last ten years support that the plume is stable and not migrating further down gradient from the source areas.

Sampling Strategies

Several decades of groundwater monitoring data are available for PJKS. Groundwater samples and water level measurements, collected in the spring and fall of 2009, were selected for discussion in this ROD. Semi-annual site-wide groundwater monitoring, as well as quarterly ICM monitoring of the three aquifers (the Alluvial aquifer, the Fountain Formation aquifer, and the Precambrian Formation aquifer), has been underway to assess the current hydrogeological conditions and the effectiveness of the ICMs for the treatment of groundwater (Shaw, 2010b and 2010c). The *2009 Annual Groundwater Report* (Shaw, 2010c) summarizes the analytical results from the 2009 sampling. Groundwater monitoring at PJKS continues on an annual basis and no significant changes to plume shapes or sizes have occurred since the 2009 sampling event.

Sources of Contamination

There are seven source areas contributing to three groundwater plumes, identified in **Figure 8**. Generally, the plumes appear to originate near specific operational locations within PJKS. These seven areas are considered the sole bedrock sources of groundwater contamination at PJKS and are identified as follows.

1. D-1 area (D-1) [TCE and NDMA source area],
2. D-4 Fuel Storage area (D-4) [TCE source area],
3. EPL area [TCE source area],
4. SCA [TCE and NDMA source area],
5. CSSA [TCE and NDMA source area],
6. OTL area [TCE source area], and
7. T-8A area [TCE and NDMA source area].

All seven groundwater sources areas are TCE source areas. Four of these locations (SCA, D-1, T-8A, and CSSA) are also NDMA source areas. Some of the source areas contribute to more than one groundwater plume. The D-1, D-4, EPL, SCA, CSSA, and T-8A source areas contribute to TCE and NDMA concentrations in the EFBC SWMU (SWMU 1). The D-1, EPL OTL, and T-8A source areas contribute to TCE and NDMA concentrations in the WFBC (SWMU 2), and the D-4, EPL, SCA, and CSSA source areas contribute to TCE and NDMA

concentrations in the LG SWMU (SWMU 3). No soil sources for groundwater contamination have been identified. **Figure 8** shows the sources and distribution of COCs.

SWMU 1 – EFBC. Current and historical data indicates that TCE and NDMA contamination in the EFBC SWMU originates from the D-1, D-4, EPL, SCA, CSSA, and T-8A source areas. In 2009, groundwater samples were collected from three EFBC SWMU monitoring wells located within and down gradient of these source areas. Results indicated elevated levels of volatile organic compounds (VOCs), TCE and NDMA were above the CBSGs. Historical data shows that the TCE concentrations in these wells have either remained consistent, or have steadily decreased since monitoring began in the early 1990s. The extent of the TCE and NDMA plumes in EFBC alluvial groundwater are considered stable. Groundwater data indicates that TCE and NDMA concentrations have remained within a narrow range from slightly above to slightly below the CBSGs since 2004.

SWMU 2 – WFBC. Current and historical data indicate that TCE contamination in the WFBC SWMU originates from the D-1, T-8A, and OTL source areas. The NDMA contamination in the SWMU originates from the D-1 and T-8A source areas. Groundwater samples collected within and down gradient of the source areas in 2009 showed concentrations of VOCs, TCE, and NDMA that exceeded CBSG values. Historical data show that the TCE concentrations in these wells have remained consistent, or have steadily decreased since monitoring began in the early 1990s.

TCE concentrations in the most down gradient alluvial well (5-M24), an OTL alluvial source area well, have been consistent over time and were below CBSGs in 2009. Data indicate that the concentrations of TCE in the WFBC plume are stable, and TCE contamination in the WFBC SWMU is not migrating further down gradient from the source areas. Data also indicate that the concentrations of NDMA in the WFBC plume at PJKS are stable and NDMA contamination in the WFBC is not migrating further down gradient from the source areas.

SWMU 3 – LG. Current and historical data indicate that TCE contamination in the LG SWMU originates from the D-4, EPL, SCA, and CSSA source areas. Data indicate that NDMA contamination in the LG SWMU originates from the SCA and CSSA source areas. Results indicated elevated levels of VOC, TCE and NDMA, which are above CBSGs. Historical data show that the TCE concentrations in these wells have either remained consistent, or have steadily decreased since monitoring began in the early 1990s. The TCE and NDMA plumes in LG groundwater are stable.

At each of the SWMUs 1, 2, and 3, several treatability investigations, pilot studies, and bench scale tests have been conducted. Additionally, an ongoing ICM for TCE remediation in bedrock groundwater at all source areas has proven to be effective in promoting in-situ

bioremediation through the introduction of substrates and microbes originally tested as part of the pilot studies. In 2008, two biobarriers also were constructed perpendicular to the East Fork of Brush Creek (from the SCA source area) and the West Fork of Brush Creek (originating from the T-8A and OTL source areas) near the PJKS boundaries in the saturated alluvium.

The objectives of the biobarriers were to reduce the source of TCE concentrations migrating within the alluvium groundwater from the Fountain Formation bedrock groundwater, and to better assess the effectiveness of the biodegradation processes. The East Fork Brush Creek biobarrier is 300 ft long, and the West Fork Brush Creek biobarrier is 150 ft long. The biobarriers were constructed using direct-push technology (DPT) and consisted of a one-time injectant of emulsified edible oil (EEO), a carbon substrate that will ferment more slowly than sodium lactate and water, and provide a carbon source for DHC for a much longer period.

Type of Contamination and Affected Media

The type of groundwater contamination at PJKS was determined by evaluating several years of groundwater monitoring data. TCE, which emerged as the most persistent and extensive PJKS groundwater contaminant, is the primary COC at PJKS. NDMA is also a COC, although not as widely dispersed as TCE.

Location of Contamination and Route of Migration

The TCE contamination extends from the source areas located in the central and eastern portions of PJKS down gradient in the eastern (SWMU 1 & 2) and northern directions (SWMU 3). Plume maps of TCE contaminant concentrations were completed from the fall 2009 sampling results (see **Figures 9, 10 and 11**). The horizontal extent of TCE in groundwater is defined as the outermost boundaries of the plume across all three aquifers, as shown on **Figures 9, 10 and 11**.

The vertical extent of TCE in groundwater is defined as the lower-most aquifer in which TCE contamination exceeding cleanup standards has been detected. The horizontal extent of NDMA in groundwater is defined as the outermost boundaries of the plume across all three aquifers, as shown on **Figure 12.** The vertical extent of NDMA in groundwater is defined as the lower-most aquifer (Precambrian) in which NDMA contamination exceeding cleanup standards has been detected. The nature and extent of groundwater contamination are described in detail in the *Supplemental Remedial Investigation Addendum, OU5 – Brush Creek Groundwater Plume* (Shaw, 2003). Because TCE is the primary COC, its distribution in the groundwater system(s) describes the greatest extent of contamination, and TCE data were used to generate contaminant distribution maps.

No significant levels of contamination have been found in surface water. Twenty-plus years of PJKS-specific monitoring data have shown that the discharge of contaminated groundwater to

surface streams does not result in an exceedence of State of Colorado Basic Standards for Surface Water. Thus, there is no significant risk to human health via surface water ingestion or direct contact and there is no threat to the environment via the transfer of contaminants from groundwater to surface water exposure scenario (Shaw, 2010d).

The elevated concentrations of TCE and NDMA in PJKS groundwater would represent a significant threat to human health via ingestion and direct contact, if exposed. However, the current risks due to groundwater contamination are negligible because there are no pathways for exposure. Both direct contact exposure and exposure via ingestion are expected to be currently non-existent in this industrial setting because groundwater is beneath the ground surface and PJKS impacted groundwater is not currently used as a private or public water supply. Future exposure will also be restricted with the implementation of the PJKS Restrictive Notice. Risks from residential use were not formally evaluated because future use will remain non-residential since the quit claim deed transferring PJKS from the USAF to Lockheed Martin restricts the current and future use of the entire former PJKS to non-residential as will the PJKS Restrictive Notice. PJKS and the surrounding Lockheed Martin properties are currently industrial sites with no residential inhabitants. Under current and reasonable future conditions, human receptors for the groundwater medium associated with contaminants from PJKS would be commercial/industrial workers. Because future land use is indefinitely restricted at PJKS, commercial/industrial workers are also identified as future receptors.

Previous Studies That Support Development of Proposed Alternative

Below is a short description of the pilot studies and ICMs implemented at each of the SWMUs that helped narrow the range of feasible groundwater remedial alternatives and design the proposed Alternative 2.

D-1 Pilot Test: The D-1 Pilot Test impacted groundwater SWMUs 1 and 2. In December 2003, 249 gallons of sodium lactate (carbon source) was injected into the source area. Groundwater performance monitoring samples were collected from two wells (including the newly installed down gradient monitoring well) from December 2003 to April 2006. The samples showed a decrease in both dissolved oxygen (DO) and oxidation-reduction potential (ORP) within 12 days of the initial injection of sodium lactate. The TCE concentrations decreased from an initial value of 12,000 micrograms per liter (µg/L) to a final value of 640 µg/L in 30 months. In addition, TCE degradation products 1,2-dichloroethene (1,2-DCE), vinyl chloride (VC), and ethene were detected in the samples. Analyses of the pilot study results indicate that in-situ bioremediation was converting TCE to ethene; however, no significant NDMA reduction appeared to be occurring. The pilot study was converted into an ICM so that treatment could continue. To date, TCE continues to decline and is below 100 µg/L. Detailed

results of the pilot tests are summarized in the *Summary and Evaluation Report, Brush Creek/Lariat Gulch Groundwater Plumes Pilot Study* (Shaw 2007d).

EPL Pilot Test: The EPL Pilot Test impacted groundwater SWMUs 1 and 2. Two monitoring wells and two injection wells were installed in the EPL area as part of the bedrock pilot study. During the study, 662 gallons of sodium lactate were injected into the wells beginning in December 2003. Groundwater performance monitoring was conducted from December 2003 to April 2006. No evidence of TCE degradation was initially observed. In addition, a strong, downward gradient exists in the EPL area (Shaw, 2007a). Based on the lack of TCE degradation observed, and this known downward gradient, it was determined that additional deeper groundwater monitoring wells were needed to evaluate the distribution of the sodium lactate in the aquifer. Four additional monitoring wells were installed in this area as part of the supplemental pilot study. Bioaugmentation was also tested as part of this effort. A bioaugmentation culture is added to enhance biodegradation in a given media. Bioaugmentation is achieved by adding specific microorganisms to the media. In this case, the microbes being injected were initially collected from the successful D-1 Pilot Study location. Those microbes were cultured in the laboratory to increase the mass of microbes. Microbes (DHC) that have demonstrated the ability to completely degrade TCE to ethene were also introduced into the Fountain Formation in the EPL area in May 2006. Additional groundwater performance monitoring samples were collected from December 2005 to October 2006. Groundwater performance monitoring samples from one well showed a decrease in TCE concentrations accompanied by the appearance of all the TCE degradation products. These results indicated that with the addition of the bioaugmentation culture, in-situ bioremediation can successfully degrade TCE in the Fountain Formation. Detailed results of the pilot tests are summarized in the *Summary and Evaluation Report, Brush Creek/Lariat Gulch Groundwater Plumes Pilot Study* (Shaw 2007d).

SCA Pilot Test: The SCA Pilot Test impacted groundwater SWMUs 1 and 3. Two monitoring wells and four injection wells were installed in the SCA area as part of the bedrock pilot study. During the study, 45 gallons of Hydrogen Release Compound® (HRC®) were injected into the wells beginning in December 2003. HRC® is another type of carbon source used to promote in-situ bioremediation to support TCE degradation. Groundwater performance monitoring samples were collected from three wells (including the newly installed monitoring wells) from December 2003 to April 2006. In all three wells, ORP remained positive in the majority of samples collected, DO did not decrease significantly, sulfate did not decrease, and there was no decrease in TCE concentrations. This data indicated that HRC® did not produce in-situ bioremediation at the SCA area. However, downward vertical gradients similar to the EPL area are also present at SCA. Therefore, it is likely that the effect of the treatment was occurring below the screened interval of the monitoring wells, although no additional wells were installed

to confirm. Detailed results of the pilot tests are summarized in the *Summary and Evaluation Report, Brush Creek/Lariat Gulch Groundwater Plumes Pilot Study* (Shaw 2007d).

In-Situ & Ex-Situ NDMA Bench Scale Test: Biodegradation was studied at the bench-scale level and conducted at the Shaw Lawrenceville Laboratory using aquifer material and groundwater collected from PJKS sources. Results of the study indicated that anaerobic bioremediation of NDMA was not successful; although TCE concentrations were reduced by orders of magnitude through aerobic and anaerobic treatments. However, in-situ bioremediation has been determined to be efficient and cost-effective in reducing TCE concentrations and is the preferred in-situ TCE treatment for PJKS groundwater. Detailed results of the in-situ bench scale test are summarized in the *Groundwater Treatment Studies Report, N-nitrosodimethylamine with Trichloroethene* (Shaw 2008).

Catalytic hydrogenation was also studied at the bench-scale level and conducted at Shaw Lawrenceville Laboratory using aquifer material and groundwater collected from PJKS sources. Testing was conducted to evaluate the use of nickel catalysts for the treatment of TCE and NDMA in groundwater. The results of the bench scale test showed that NDMA was completely denitrified, generating ammonia as an end-product. Treatment of greater than 95 percent of the TCE was also observed, with no formation of chlorinated daughter products. The test results indicated that treatment of NDMA to 0.001 µg/L using nickel catalysts is attainable. Detailed results of the ex-situ bench scale test are summarized in the *Groundwater Treatment Studies Report, N-nitrosodimethylamine with Trichloroethene* (Shaw 2008).

Ex-Situ NDMA Pilot Test: The ex-situ NDMA bench-scale study (Section 5.3) indicated that evaluation of the nickel catalyst technology in a field demonstration was warranted with the recommendation that the field trial incorporate water softening as a pretreatment step. Design and construction of a scaled-up version of the bench-scale nickel catalyst technology system began in January 2006. The initial construction was completed, and reactor operation was initiated on April 19, 2006 and terminated on January 12, 2007. The reactor was operated in a semi batch mode during the workweek. The reactor was either shut down or operated in recirculation mode (with the hydrogen source turned off) during the weekends for safety reasons. The nickel catalyst field demonstration system attained some of the overall objectives of the project. Specific findings of the field demonstration include the following:

- The nickel catalyst proved effective in treating commingled NDMA and TCE in groundwater under field conditions.
- Treatment of NDMA to concentrations below 0.7 µg/L was attained and maintained for approximately 11 weeks (October 2006 through January 2007). Approximately 2,100 gallons of water were treated during this period.

- NDMA degradation kinetics observed in the field demonstration system are consistent with those observed in the laboratory bench-scale system.

Dissolved nickel in the effluent, as observed during the demonstration, is problematic. The concentration of dissolved nickel substantially exceeded the CBSG value of 100 µg/L. The system performance resulted in a conclusion that full scale deployment of the technology at PJKS is not feasible. Furthermore, the alluvial aquifer chosen for this effort was approximately 25 ft bgs and allowed for easy groundwater recovery with very high hydraulic conductivity rates (11.4177 ft/day) (Table 10.3.5.4.3-1, Parsons, 1999). Detailed results of the pilot test are summarized in the *Groundwater Treatment Studies Report, N-nitrosodimethylamine with Trichloroethene* (Shaw 2008).

For more details describing the pilot tests and ICMs refer to the FFS located in the ARs.

2.6 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

Land Uses

The PJKS property is surrounded entirely by Lockheed Martin property. The LMSSC property is used for industrial purposes, although some undeveloped areas exist within the approximately 5,200-acre parcel. Both PJKS and LMSSC properties are zoned, by the county, for industrial use (I-2 industrial).

Recreational areas located within approximately 5 miles of PJKS include Waterton Canyon, Roxborough State Park, Deer Creek Canyon, and Chatfield State Recreation Area. These areas are heavily used for hiking, fishing, biking, picnicking, boating, and other seasonal recreational activities. Nearby residential subdivisions and areas include: Deer Creek Mesa, Sunshine Acres, Plum Creek Acres, View Ridge, Roxborough Village, Roxborough Park North, Deer Creek Canyon, South Deer Creek Road, areas southeast of Waterton Canyon, and areas southeast of Chatfield Reservoir.

The future use of the PJKS property is expected to remain industrial. However, if the current owner of the PJKS property, Lockheed Martin, were to cease to be the owner, it is possible that all or a part of the Site could be used for residential purposes. The PJKS Restrictive Notice would have to be modified or terminated in accordance with terms of Paragraph 2 of the Restrictive Notice prior to change in land use.

The current owner of the PJKS property, Lockheed Martin, has agreed to the industrial use cleanup level for the site (included in the quit claim deed) and has requested that CDPHE issue a Restrictive Notice on the PJKS property (PJKS Restrictive Notice) and the adjacent portion of Lockheed Martin's property pursuant to Section 25-15-321.5 of the Colorado Revised Statutes (Colorado Environmental Covenant Act). This includes impacted groundwater leaving PJKS

property per the March 9, 2010 signed memorandum of agreement on the property (LMSSC, 2010). For ease of implementation, the PJKS Restrictive Notice will specify that all of the property that comprises PJKS will only be used for industrial purposes until unlimited use/unrestricted exposure levels are met. The Restrictive Notice will be issued on the property soon after the final corrective measure for the entire facility has been selected and approved in this ROD. The current or future owner must also modify or terminate the PJKS Restrictive Notice in accordance with of terms of Paragraph 2 of the Restrictive Notice prior to change in land use.

Surface Water and Ground Water Uses

In general, surface water in the area is not used for human or livestock consumption, or for crop irrigation. There are horses owned by LMSSC employees that are pastured in Lariat Gulch that may utilize some surface waters, but the horses are not considered at risk because no surface water contamination has ever been detected in twenty years of monitoring. Although surface water contamination has not been detected, the employees pasturing the horses are informed that there is a potential for contamination so they can make their own informed risk management decisions.

Groundwater in the area is not a public drinking water source and the Restrictive Notice will prohibit use of groundwater for human consumption. Future use of groundwater and surface water is expected to remain the same as current use as long as Lockheed Martin owns the property. Should Lockheed Martin cease to own the property, residential use of all, or a portion of the PJKS Site property is possible, as is the potential for future use of the groundwater beneath the site as a drinking water source.

2.7 SUMMARY OF SITE RISKS

PJKS is currently an industrial site with no residential inhabitants. Risk screens and assessments were performed for both soil and groundwater at PJKS. Human and ecological receptors were evaluated with respect to existing contaminants. Because risks associated with exposure to soils have been addressed by interim action, the following sections focus mainly on the human health and ecological risk for groundwater.

Summary of Human Health Risk Assessment

A Baseline Risk Assessment (BRA) for human health risks was completed for groundwater and soil at PJKS in the *Supplemental Remedial Investigation (SRI) Report* (Parsons, 1998, 1999a, 1999b, 1999c). The BRA included an evaluation of risks to current and expected future human receptors (site workers, visitors, hunters, and trespassers) posed by site-related contaminants in soil and groundwater.

To complete the remedial investigation phase for the combined soils and accelerate any necessary IA/ICM interim action(s), site-specific remediation standards were developed for PJKS. The State of Colorado's Proposed SROs Policy Document (State of Colorado, 1997) was used to calculate Tier 2 SROs for both an unlimited use/unrestricted exposure scenario and an industrial use scenario for human exposure to PJKS soil. The sole contaminant of concern is PCBs in soil. Tier 2 STG values also ensure concentrations of contaminants in soil do not adversely impact PJKS groundwater. These values are consistent with EPA Soil Screening Levels (SSLs) for residential and industrial use and for preventing further contamination of ground water.

Based on the current and foreseeable land uses at PJKS, the Tier 2 Industrial SRO and the Tier 2 STGs have been selected as the cleanup criteria for the facility. The results of each hazardous substance list compound and hazardous waste constituent detected in every soil sample collected at the site were compared to the selected criteria to identify soil SWMUs, or portions of soil SWMUs, where remediation might be necessary. This "point by point" comparison of the concentration of potential COCs in PJKS soil to the selected cleanup criteria resulted in the identification of only a small number of select areas with residual soil contamination requiring further work. The only COCs detected above the industrial use SROs in the soil SWMUs were PCBs. The point by point comparison also showed that the concentration of constituents in large areas within PJKS were actually below the unlimited use/unrestricted exposure levels so that no-further remediation was required.

Once the point by point comparison was complete, a determination of whether the quantity and quality of the available soil sample data was adequate to support final remedial decisions. For example, the data was reviewed to determine in the location of hot spot of contamination discovered and if the extent of soil contamination above industrial use SROs had been delineated. The evaluation determined that data is of sufficient quantity and quality to support remedial decisions for most SWMUs. Additional investigations were conducted to fill remaining data gaps so that all areas within the PJKS soil SWMUs with PCB concentrations above the associated industrial use SROs were fully delineated.

Summary of Human Health Risk Associated with Groundwater

Groundwater has been screened against federal and State ARARs, including federal MCLs and State CBSGs, which are established to be protective of human health and waters of the State of Colorado (State of Colorado Regulation 41, Title 5, Code of Colorado Regulations [CCR] 1002-41). TCE, 1,1-Dichloroethene, and VC are in exceedence of the MCLs and CBSGs. In addition to TCE, NDMA concentrations have exceeded the CBSGs. **Table 6** summarizes the analytical COC concentration ranges in groundwater at each of the source areas from September 2009 (data was collected as part of the Groundwater Performance Monitoring of the

ICMs). Contaminants of potential concern in groundwater are inaccessible to both land and water dwelling species at the site and do not pose a current risk.

The following potential routes of exposure have been identified for current and future receptors at PJKS:

- Ingestion of groundwater,
- Inhalation of TCE vapors from groundwater, and
- Dermal contact with groundwater.

Groundwater Ingestion

The impacted groundwater in each of the PJKS groundwater SWMUs is classified as "Domestic Use Quality" by the State of Colorado and has a federal classification of "Class II.A, current source of drinking water." There is a significant future risk of human exposure to contaminated groundwater if future use allows ingestion. Based on data from the Fall 2011 groundwater monitoring event, the excess cancer risk for a hypothetical person consuming PJKS groundwater at the maximum concentrations for NDMA and TCE may present a risk greater than the acceptable range in CERCLA, which is from one in one million to one in ten thousand.

There is no current risk associated with the PJKS groundwater contamination because the entire PJKS is owned and controlled by Lockheed Martin. No person or entity uses the groundwater on PJKS as a water supply so there is no risk via ingestion or direct contact due to extraction of groundwater.

Inhalation TCE Vapors

TCE and its breakdown/daughter products, 1,2-DCE and VC evaporate readily into the air (EPA, 2002). One of the known pathways of human exposure to these constituents is via volatilization from contaminated groundwater into the pore spaces of soil above the groundwater, then into the air above the ground surface via continued volatilization. If these chemicals reach the ground surface in an open area, the contaminants dissipate rapidly in the large volume of outdoor air and are not a concern to human health or the environment. If the constituents surface beneath an inhabited building, there is a potential for them to migrate through cracks or gaps in the buildings floor and contaminate the breathing air of the buildings inhabitants. The potential for PJKS workers to be exposed to VOCs in the PJKS groundwater is considered to be negligible for the following reasons:

- There are inhabited buildings located above VOC-contaminated groundwater in the Fountain Formation in the SCA and the EPL areas. While no indoor air samples have

been collected, the potential for migration of VOCs from Fountain Formation groundwater is very low because the groundwater primarily flows through small fractures in the rock that are located inches to several feet apart. As a result, the available area for the VOCs to evaporate from the groundwater surface is very small, so little evaporation occurs.

- The only habitable building on PJKS situated above alluvium contaminated with VOCs is the Missile Storage Building (Building T-42), which is located near the CSSA. While no indoor air samples have been collected, the concentration of TCE in the alluvial groundwater beneath the Missile Storage Building is approximately 16 µg/L. Through research, CDPHE has determined these concentrations are too low to cause indoor air contamination levels considered to be a threat to human health for residential or unrestricted use. In addition, the Missile Storage Building is not inhabited by workers on a regular basis.

There would be a significant future risk of human exposure due to inhalation of TCE vapors with construction and habitation of new buildings without proper engineering controls over portions of the alluvial groundwater plume highly contaminated with TCE. The highest concentration of TCE detected in alluvial groundwater during the Fall 2011 groundwater monitoring event was 560 µg/L. While no site-specific indoor air sampling has been conducted at the PJKS site, indoor air samples from other sites in Colorado with similar hydrogeology and TCE groundwater concentrations have indicated TCE levels in indoor air up to 50 µg/cubic meters. A TCE concentration of 50 µg/cubic meter in indoor air would correspond to an excess cancer risk greater than 1 in 10,000 for a residential receptor and greater than 1 in 100,000 for an industrial receptor.

Dermal Contact

There is a negligible potential for dermal contact with groundwater during construction activities. Depth to groundwater is typically greater than the depth of construction activities. Lockheed Martin maintains a current 'black zone map' that is used to indicate areas where digging is prohibited without appropriate engineering controls and worker protection. This map is reviewed in the planning phase of all construction projects on site. If excavation is required in an area where soil contaminant concentrations exceed industrial use (black zone), then additional precautions are taken during the excavation such as using personal protective equipment, decontaminating equipment and logging worker hours (Shaw, 2010a). The restrictive notice is needed to assure enforceability by the regulatory agencies.

Lockheed Martin employs fences and security personnel to enforce strict rules that prohibit unauthorized personnel from entering the site. Thus, a member of the public is unlikely to

come into dermal contact with the contaminated groundwater, and there is no complete pathway for exposure.

Groundwater at the site is inaccessible to terrestrial receptors so there are no completed pathways for aquatic receptors. Depth to groundwater is approximately 30 ft below the ground surface.

Summary

As a part of the 1998 BRA, nonintrusive and intrusive industrial workers, adult and child residents/trespassers, and a future resident were evaluated as potential receptors that could be exposed to site-related contaminants in groundwater, surface water, and sediment under current and future land use scenarios.

Based on the quantitative risk evaluation, it was determined that all of the receptor-specific reasonable maximum exposure and central tendency hazard quotient/hazard indices for non-cancer adverse effects were less than 1, which means that the potential hazard associated with exposure to the source area and groundwater OUs was determined to be less than the EPA (l991b) acceptable range of value for non-cancer hazard (Parsons 1998). Cancer risk range for current receptor is below the acceptable 10-6 (one in one million) to 10-4 (one in ten thousand) risk range since no one is currently drinking the groundwater, inhaling vapors from groundwater or directly contacting groundwater.

There are no current residents within PJKS and all potential exposure routes for the future resident were determined to be incomplete. Based on data from the Fall 2011 groundwater monitoring event, the excess cancer risk for a hypothetical person consuming PJKS groundwater at the maximum concentrations for NDMA and TCE may present a risk greater than the acceptable range in CERCLA, which is from one in one million to one in ten thousand.

The response action selected in this ROD is necessary to protect the public health, welfare and the environment from actual or threatened releases of hazardous substances into the environment.

Summary of Ecological Risk

In 1995, an endangered species survey was performed at PJKS as a component of the *Final Installation Report* (Parsons, 1995). A baseline ecological risk assessment (Parsons, 1998) and a screening risk assessment for birds (Shaw, 2005b) were prepared to evaluate potential risk to ecological receptors posed by site-related contaminants in soil. Ecological exposures may be impacted directly or indirectly. Direct exposure pathways to receptors from contaminated soil or water include plant uptake, and ingestion exposure routes. Indirect exposure pathways for

ecological receptors can occur during consumption of contaminated plants and/or ingesting prey that have accumulated contamination in their tissues.

The endangered species survey listed all federally-listed threatened or endangered species potentially occurring in the PJKS area. The study eliminated the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) as a receptor of concern because no suitable habitat was identified, nor were any individuals observed. It was also concluded that no suitable habitat exists on site for either peregrine falcons (*Falco peregrinus*) or bald eagles (*Haliaeetus leucocephalus*), nor were any individuals observed. However, visitation to the site for foraging could not be ruled out because nesting sites for both bird species are located within proximity of PJKS. Other eliminations of special status species due to lack of riparian habitats at PJKS included the least flycatcher (*Empidonaz minimus*, listed as sensitive by the Colorado Natural Heritage Program [CO-SS]), American redstart (*Steophaga ruticalla*, CO-SS), and little bluestem (*Andropogon gerardii schizoparuim*, CO-SS).

No wetland communities are present within the PJKS boundary.

Summary of Ecological Risk Associated with Soil

During the baseline ecological risk assessment study, it was determined that vegetation throughout much of the developed portions of the facility have been damaged or effectively eliminated due to activities associated with PJKS operations. Compaction resulting from grading and vehicle traffic also has affected shallow soils throughout PJKS, further limiting vegetation and reducing the attractiveness of these areas for wildlife (Parsons, 1998).

Shallow soil intervals of 0 – 1.5 ft bgs were characterized in the BRA for evaluation of soil contaminant exposures to surface-foraging and shallow burrowing wildlife and for many forage plants like grasses. Incidental ingestion of contaminated soil during foraging, burrowing, and preening/grooming is the primary direct route of exposure to wildlife.

The receptors evaluated were chosen as indicator species, which encompassed terrestrial and avian wildlife. Plant and invertebrate communities were not considered to be present at PJKS, although the food chain exposures included plants and invertebrates. The wildlife indicator species identified as part of the terrestrial scenario were:

- Deer mouse (Peromyscus maniculatus),
- Mule deer (Odocoileus hemionus), and
- Red fox (Vulpes vulpes).

The avian wildlife species identified during the screening risk for birds (Shaw, 2005b) were:

- American goldfinch (Carduelis tristis),

- Killdeer (Charadrius vociferus),
- Red-winged blackbird (Agelaius phoeniceus),
- Western meadowlark (Sturnella neglecta),
- Spotted towhee (Pipilo maculatus),
- Black-billed magpie (Pica hudsonia), and
- American kestrel (Falco sparverius).

None of the soil ecological contaminants of potential concerns is an ecological COC for the indicator species. A conservatively selected set of ecological screening levels for soil were developed for PJKS using available literature. All PJKS soil potential COCs were below the screening levels and sufficient evidence exists to conclude that further evaluation of risk to mammals or birds from chemicals detected in soil and sediment is not warranted. The conclusion of the ecological risk assessment was that no unacceptable risks to ecological receptors were identified.

Summary of Ecological Risk Associated with Groundwater

The BRA included an evaluation of chronic risks to current and expected future ecological receptors posed by site-related contaminants in groundwater. Exposure to ecological receptors from alluvial groundwater can only occur if contaminated groundwater discharges to surface water, or if the depth to the affected aquifer is within the root zone for plants. Pathways are not considered complete for bedrock groundwater because roots are unlikely to penetrate bedrock formations to the saturated zone. Exposure pathways from groundwater to ecological receptors can be considered a potentially complete pathway where alluvial groundwater elevations in unconsolidated materials near drainage bottoms along Brush Creek and its tributaries. Stream channels and riparian vegetation likely have seasonal direct root contact with shallow alluvial groundwater in portions of PJKS. Additionally, alluvial or bedrock groundwater discharge may contribute to surface water in drainages; such discharge is evaluated as surface water. The BRA concluded that site related chemicals in site alluvial groundwater, sediment, surface water do not pose an unacceptable risk to the receptors potentially exposed (Parsons, 1998).

PJKS stream channels have intermittent water bodies that occur during seasonal snowmelt runoff and heavy precipitation events. Aquatic species were not evaluated as on-site receptors since aquatic habitats are not expected to support populations of fish or other aquatic organisms. The only indicator aquatic species observed during the BRA was the mallard (*Anas platyhynchos*). The single on-site location for which there was enough water to be considered a suitable open-water habitat for the mallard was present at the T-8A Containment pond, which has since been drained.

There is a potential for mule deer and the red fox to use on-site water bodies as a drinking water source. Sufficient evidence exists to conclude that further evaluation of risk to aquatic species or mammals from chemicals detected in on-plant water bodies is not warranted. As a result, no further evaluation of the analytical data is necessary to address ecological risk (Parsons, 1998; Shaw, 2005a).

2.8 REMEDIAL ACTION OBJECTIVES

RAOs are medium-specific remedial goals for protecting human health and the environment, have been established.

Soil RAOs

RAOs for soil were based on CDPHE's Tier 2 SROs (CDPHE, 2003), and were established specifically for PJKS using guidance from the Proposed Soil Remediation Objectives Policy Document (State of Colorado, 1997). The Tier 2 SROs are human health risk-based concentrations applied to possible land uses, which for PJKS are unrestricted at some sites and industrial at others. The Tier 2 Soil-to-Groundwater (STG) values also were calculated to ensure the CBSGs were not exceeded as a result of any residual soil contamination. Based on the current and foreseeable land uses at PJKS, the Tier 2 SROs were selected as the cleanup criteria for PJKS. The Tier 2 SRO values were approved by CDPHE and EPA (CDPHE, 2003) and are summarized in the *Combined Soils Additional Investigation (CSI) Report* (Shaw, 2005b). The RAOs for soil SWMUs are:

- Excavation and proper off-site disposal of contaminated soils where practicable. Most of these areas have been excavated to meet residential standards.

- Prevent exposure to soils above industrial standards through engineering and/or institutional controls (See Also Table 4).

Groundwater RAOs

Remedial Action Objectives (RAOs) provide a general description of what a remedy will accomplish. RAOs may be achieved by reducing exposure or by reducing chemical concentrations. Preliminary RAOs were established for the entire groundwater medium at PJKS at a meeting among USAF, EPA, and CDPHE on December 7, 2005. Additional refinement of the RAOs and methods for demonstrating when RAOs have been achieved were presented in letters provided by CDPHE and EPA on January 25, 2006 and February 8, 2006. The data necessary to prepare the groundwater medium RAOs were available from the numerous investigations, risk analyses, and treatability studies that have been completed or are in progress. The end result of the data evaluation and meetings are the final groundwater RAOs

for the SWMUs or OUs at PJKS, specified in this section of the PJKS ROD, and previously documented in the Proposed Plan (Shaw 2011b).

The RAOs for the PJKS site include objectives to contain contaminated ground water and objectives to restore groundwater to beneficial use. Biobarriers were installed as an interim measure to prevent contaminants moving from PJKS property to LMSSC property in the past when the Air Force owned the PJKS property. Other measures for physical containment options were considered while the plumes were actively expanding. However, the plumes have long since demonstrated stability, i.e., the extent of the plume is advancing no further. To assure protectiveness, the down gradient property owner (or LMSSC) has agreed to an LUC to prevent use of, and exposure to PJKS sourced groundwater contamination beyond the original PJKS property boundary. The USAF, EPA and CDPHE have agreed that the employment of a traditional containment technology to prevent contaminant migration is not required for the PJKS alluvial groundwater plumes.

The impacted groundwater in each of the PJKS groundwater SWMUs is classified as Domestic Use Quality by the State of Colorado and Class II.A, current source of drinking water under the federal classification system. Since the groundwater at PJKS is considered drinking water quality, the long-term goal of the selected remedy is to achieve unlimited use/unrestricted exposure levels for NDMA and TCE in all PJKS groundwater wherever it is achievable.

To employ more realistic short-term goals for remediation, both CERCLA and the State of Colorado have established an initial point of compliance which intentionally coincides to the original facility property boundary at the time the Air Force owned PJKS. Because LMSSC also has contaminant plumes, the point of compliance aids in identifying separate Air Force responsibilities for response actions. LMSSC now owns all of the property. USAF, EPA and CDPHE, have agreed this is an appropriate point of compliance.

The USAF, EPA and CDPHE recognize that it is not always possible to remediate all COCs in groundwater to achieve unlimited use/unrestricted exposure levels. Therefore, USAF, EPA and CDPHE, with community agreement, developed the following PJKS-specific RAOs for PJKS groundwater:

- Reduce the concentration of TCE contaminated groundwater in the down-gradient portion of the source areas at the transition points (where bedrock groundwater transitions to the alluvial system).
- Reduce the concentrations of TCE in bedrock groundwater source areas to concentrations that achieve CBSGs for groundwater.
- Protect human health by preventing contact with, and ingestion of, TCE or NDMA contaminated groundwater until unlimited use/unrestricted exposure levels are achieved.

- Contain TCE and NDMA in the alluvium through the continued monitoring of the plume stability until the groundwater is remediated to beneficial use. NDMA in the alluvial aquifer is currently expected to reach CBSGs in a reasonable time frame in alluvial groundwater. NDMA responds slowly and inconsistently to bioremediation. Given the uncertainties, the remedy will be re-evaluated during 5 Year Reviews.
- Utilize a technical impracticability waiver for restoring NDMA within bedrock groundwater in a reasonable timeframe. Protectiveness in this zone will rely on Land Use Controls and monitoring.

Estimates for time frames to reduce contaminant concentrations to asymptotic levels or CBSGs in alluvial groundwater ranges from 10 to 20 years. Based on data from the last decade, the plumes appear to be stable. Groundwater is not used on PJKS. The groundwater RAO to protect human health is intended to prevent future use until concentrations are reduced to the point use can be unrestricted and exposure unlimited. Use will be restricted through the LUCs imposed by the PJKS Restrictive Notice. The ultimate achievement of the RAOs and attaining CBSGs for TCE and NDMA are expected to occur throughout the plumes except where a waiver based on technical impracticability is justified.

Under CERCLA, Applicable or Relevant and Appropriate Requirements (ARARs) are used to establish the acceptable chemical concentrations for use in measuring whether some RAOs have been achieved. The State of Colorado has promulgated groundwater standards (e.g. CBSGs), which will be the basis of the media cleanup standards (MCSs) for individual COCs in PJKS groundwater. The CBSGs (5 Code of Colorado Regulations 1002-41) apply to all groundwaters of the state, regardless of whether it is currently being used and can be extracted at a useable quantity or rate. Thus, the CBSGs are the primary regulatory related standards of measure for PJKS remedial actions. The CBSGs for TCE and associated degradation products are the same concentrations as EPA's MCLs used to establish drinking water standards. NDMA has a promulgated standard under the CBSGs; but it is not promulgated as a federal standard under the Safe Drinking Water Act. The concentration of PJKS groundwater COCs that represent achievement of human health risk-based unlimited use/unrestricted exposure levels are provided in **Table 7**.

2.9 ALTERNATIVES

Alternatives for Contaminated Soil

Alternatives are not developed in this ROD for the soil SWMUs, as the IA/ICMs implemented pursuant to the Order on Consent were determined to be appropriate to incorporate as the final remedy for the soil SWMUs.

The 53 soil SWMUs were divided into four (4) OUs, OU-1, 2, 3 and 6. Previous investigations and Interim Corrective Measures (ICMs) resulted in one of three response actions (**Table 2**). The alternatives considered in the IA/ICMs for the PJKS soil SWMUs were:

- Closure to unlimited use/unrestricted exposure levels via excavation and proper off-site disposal of contaminated soil;
- Restricted Closure with Land Use Controls (LUCs); or
- Restricted Closure with LUCs and Limited Cover.

This ROD incorporates the soil SWMU remedies implemented and selects a restrictive notice as an additional layer of institutional control for the soil SWMUs.

Alternatives for Contaminated Groundwater

The alternatives being considered for evaluation include:

- Alternative 1 - No Action
- Alternative 2 - In-Situ Bioremediation with Restrictive Notice

A streamlined FFS approach was performed to identify remedial alternatives for the seven groundwater source areas, and the alluvial groundwater migrating off the site. Existing information on remediation technologies and site characterization data were used in the FFS to eliminate technology alternatives that cannot be effectively implemented at PJKS. Identification of treatment alternatives was focused on process options that are known to be suitable for PJKS groundwater conditions. The traditional procedure of identifying general response actions, technologies, and process options through successive screening rounds in the feasibility study has instead been accomplished through previous pilot studies, bench scale studies, and research of alternative technologies. Various potential technologies, including chemical oxidation and aerobic co-metabolism were evaluated and screened out in the Pilot Study Work Plan (Shaw, 2003b). The presumptive strategy of pump and treat may be technically feasible, but the estimated cost is orders of magnitude greater than the in-situ remedies tested and required longer time frames to achieve similar final results. Site conditions have been fully characterized and several treatability studies and interim remedial actions have been completed resulting in only a limited number of alternatives that are practicable and realistic (EPA, 1990). These alternatives also fit the site conditions being addressed (as determined from the previously conducted remedial/site investigations), use the results from previous treatability studies and ICMs, and meet the established RAOs. A No Action alternative is also included to provide a baseline for comparison purposes pursuant to the NCP 40 Code of Federal Regulations (CFR) Section 300.430(e)(6).

As required by the NCP, the No Action Alternative was retained as a remedial alternative in the FFS and Proposed Plan to serve as a baseline for comparison to other remedial alternatives. The No Action Alternative does not include any active remediation, implementation of land-use controls, or monitoring. No CERCLA action would be taken at the site to reduce or control potential risks.

In the process of determining Alternative 2, numerous investigations, bench scale studies, pilot studies, and an evaluation of existing ICMs were explored and have shown that current interim measures implemented at the seven groundwater source areas at PJKS are appropriate and effective for treating TCE-contaminated groundwater. These ICMs are already in place and are being operated as a requirement of the PJKS Order on Consent. The existing interim remedial system would not require any additional components, modifications or extra infrastructure and could continue as a full scale treatment system with sustained operations and maintenance performed as a requirement of the PJKS Order on Consent.

The components of Alternative 2 are:

- Injecting a carbon source, such as sodium lactate, emulsified vegetable oil or equivalent, and a bioaugmentation culture, such as DHC as needed, into the subsurface. Injection will continue to focus on the seven identified bedrock groundwater source areas.
- Installing additional injection or monitoring wells in other areas of the plume(s), as needed, to improve the effectiveness of the remedy. Treatment mixtures will be delivered, if necessary, using permanently installed wells or temporary injection points. At present, the existing well network is believed sufficient for injection and monitoring.
- Monitoring to determine changes within the plume and the effectiveness of the remedy in reducing concentrations of TCE and NDMA. The frequency of treatment is based on evaluation of monitoring data. Other parameters may be monitored in discrete events to evaluate rates and mechanisms of biodegradation.
- LUCs implemented through the Colorado Environmental Covenant Act described below for the soil and ground water SWMUs.
- NDMA found in the bedrock aquifers is subject to a TI waiver to achieve the CBSG in a reasonable timeframe.

Result of previous pilot studies and ICMs that were conducted at PJKS indicate that sodium lactate is an effective substrate for enhancing the biodegradation of TCE. Complete reduction of TCE has been observed. Currently ICMs are in place and operating at all seven groundwater source areas as required by the PJKS Order on Consent. In-situ bioremediation is being stimulated in the Fountain Formation and Precambrian aquifers at these source areas by injecting sodium lactate, emulsified vegetable oil and DHC (if necessary) in specific wells in these areas. In addition, two biobarriers were constructed by injecting a mixture of emulsified

vegetable oil, water, and DHC through temporary DPT points at the transition point of the Fountain and Alluvial aquifers to enhance in-situ bioremediation of TCE entering alluvial groundwater plumes originating from the SCA and the OTL/T-8A source areas. The East Fork Brush Creek biobarrier (SWMU 1) is 300 ft long, and the West Fork Brush Creek biobarrier is 150 ft long (SWMU 2). The biobarriers consist of an injectant of emulsified vegetable oil, a carbon substrate that will ferment more slowly than sodium lactate and water, and provide a carbon source for DHC for a much longer period.

Initial results of the bedrock pilot study indicated in-situ bioremediation was not successfully treating NDMA; however, additional evaluation of in-situ technologies was conducted. Results of the in-situ biodegradation study confirmed that bioremediation of NDMA was not successful. Detailed results of the in-situ bench scale test are summarized in *Groundwater Treatment Studies Report, N-nitrosodimethylamine with Trichloroethene* (Shaw, 2008a). Based on the results of the pilot study, USAF requested, and EPA and CDPHE approved, a TI Waiver which agrees the CBSG for NDMA in groundwater within the bedrock formations at PJKS is technically impracticable to achieve. The TI Waiver does not apply to NDMA contaminated groundwater in the alluvial aquifer at PJKS.

Where complete source removal or treatment is impracticable, the EPA requires that use of migration or containment measures be considered. The annual groundwater monitoring and the quarterly ICM monitoring programs ongoing at PJKS show that the alluvial TCE and NDMA plumes from the operations at PJKS are stabilized; however, the NDMA plumes do extend beyond the PJKS property boundary. Therefore, the USAF evaluated the potential of a boundary containment groundwater extraction system within the PJKS facility and treatment before reaching the PJKS property boundary. In the case of PJKS, the NDMA plumes are stable and extend only a short distance beyond the PJKS boundary. The USAF reached an agreement with the down gradient property owner LMSSC to allow a Restrictive Notice to be issued on the property by CDPHE that will contribute to the final remedy for NDMA in alluvial groundwater. Lockheed Martin will request that CDPHE issue a Restrictive Notice on the property where the alluvial groundwater is contaminated with TCE or NDMA to prevent future use of the contaminated alluvial groundwater for any purpose.

The Restrictive Notice portion of the selected remedy for both the soil and groundwater SWMUs will be accomplished pursuant to the Colorado Environmental Covenant Act, Sections 25-15-317 through 322 of the Colorado Revised Statutes. Restrictive Notices are legal documents issued by CDPHE at the request of a property owner (in this case Lockheed Martin) that specifies all of the restrictions on the use of the land, or the groundwater beneath the land and/or maintenance of engineering controls on a property where the environmental cleanup has not achieved unlimited use/unrestricted exposure levels. Restrictive Notices are attached to the

deed of a property and remain enforceable in perpetuity by CDPHE against all future property owners and users.

The current owner of the PJKS property, LMSSC, has requested that CDPHE place a Restrictive Notice on the PJKS property (the PJKS Restrictive Notice).

The same PJKS Restrictive Notice that has been selected to enforce LUCs for the soil SWMUs will also be used to prevent human exposure to TCE and NDMA in bedrock and alluvial groundwater in perpetuity, or until unlimited use/unrestricted exposure levels are achieved. With respect to the selected remedy for groundwater SWMUs, the PJKS Restrictive Notice will prohibit future use of groundwater throughout the entire former PJKS property and ensure that workers performing excavation actions do not come into contact with contaminated groundwater without appropriate engineering controls. Prohibition of groundwater use will be accomplished via the same internal LMSSC Dig Permit detailed in the description of the selected remedy for the soil SWMUs. The PJKS Restrictive Notice will be issued by the CDPHE at the request of the property owner, LMSSC, and gives the CDPHE the right to enforce, in perpetuity, restrictions on the use of the land. LMSSC has determined that the restriction on productive use of groundwater and dig-permit program will be applied to the entire property that encompasses PJKS for ease of implementation of the Restrictive Notice.

Description of Groundwater Remedy Components

The major components of each alternative are summarized in **Table 5**.

Common Elements and Distinguishing Features of Each Groundwater Alternative

The common elements and distinguishing features of each alternative are summarized in **Table 8**.

Expected Outcomes of Each Groundwater Alternative

Alternative 1: No Action

The No Action alternative is not protective of both human health and the environment. Under this alternative, human receptors are not protected from contaminants in groundwater at PJKS, and no monitoring of the contaminants in the groundwater would be completed.

Alternative 2: In-Situ Bioremediation with Restrictive Notice

The continuation of the existing in-situ bioremediation system at PJKS under the PJKS Order on Consent with a Restrictive Notice to prevent contact with contaminated groundwater is expected to be protective of both human health and the environment. The in-situ bioremediation system relies upon anaerobic reductive dechlorination to accelerate degradation of TCE and its associated daughter products. Reductive dechlorination irreversibly reduces the toxicity and volume of TCE by converting it into a series of breakdown products which are also

dechlorinated until finally only ethene, which is relatively non-toxic, remains. It is anticipated that within approximately 10-20 years TCE levels in the source areas will be reduced to asymptotic levels or will have achieved the CBSGs (Appendix B). A Restrictive Notice will be used at PJKS in perpetuity to specify only industrial use future land use with no use of the groundwater.

Data from previous studies show the restoration potential of the source areas is such that achieving the CBSG for NDMA in bedrock groundwater in a reasonable timeframe is technically impracticable from an engineering feasibility perspective. Contaminant source constraints combined with geological constraints may limit the ability to treat NDMA within the alluvial aquifer.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

Each of the groundwater alternatives considered for this ROD are evaluated and compared based on the nine NCP criteria listed below. The first two criteria, (1) overall protection of human health and the environment and (2) compliance with ARARs (unless waived), are threshold criteria that must be met for the selected remedies. The selected remedies must then represent the best balance of the remaining primary balancing and modifying criteria.

Evaluation and Comparison Criteria

The following section describes the evaluation and comparison criteria, listed below:

1. Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each potential exposure pathway are eliminated, reduced, or controlled through treatment or engineering controls or land use controls.
2. Compliance with ARARs addresses whether or not a remedy will comply with identified federal and state environmental and sitting laws and regulations.
3. Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain on site following remediation and the adequacy and reliability of controls.
4. Reduction of toxicity, mobility, and volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.
5. Short-term effectiveness addresses the period of time needed to complete the remedy and any adverse impact on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6. Implementability refers to the technical and administrative feasibilities of a remedy, including the availability of materials and services needed to carry out a particular option.
7. Cost evaluates the estimated capital costs, operation and maintenance costs, and present worth costs of each alternative.
8. Regulator acceptance indicates whether the State (CDPHE), based on its review of the information, concurs with, opposes, or has no comment on the preferred alternative. EPA, while working in concert with CDPHE, the lead regulatory agency, must approve the remedy for PJKS.
9. Community acceptance is based on whether community concerns are addressed by the selected remedy and community concurrence or opposition to the remedy.

Evaluating the Alternatives

Table 9 presents a summary of the detailed analysis of the groundwater alternatives.

- Alternative 1: No Action
- Alternative 2: In-Situ Bioremediation with Restrictive Notice

Each alternative is evaluated against the nine criteria according to the ability of the alternative to achieve the removal action objectives. The comparative analysis that was completed for groundwater alternatives is summarized below.

Overall Protection of Human Health and the Environment

Alternative 1 does not provide for overall protection of human health and the environment. There will be no decrease in contaminants in the source areas (other than potential natural biodegradation), and there would be no monitoring of contaminants. Alternative 2 is protective of human health and environment because it reduces the concentrations of the groundwater COC, TCE, and its daughter products in groundwater source areas and distal portions of the plume, as well as monitors contaminants in the groundwater. The Restrictive Notice restricts land use to industrial use only, prohibits groundwater use for any use, and protects on-site industrial workers from contact with contaminated groundwater. A cleanup time frame at the point of compliance using the bedrock source area treatment has been estimated for TCE based on the existing ICM treatments. A cleanup time frame for TCE and its daughter products at the PJKS point of compliance using the bedrock source area treatment has been estimated at approximately 10-20 years based on the evaluation of the effectiveness of the existing ICM treatments. The cleanup timeframe for the groundwater COC NDMA cannot be determined.

Compliance with ARARs

Alternative 1 is not compliant with the chemical-specific ARARs, specifically the CBSGs.

Alternative 2 would comply with all potential ARARs except for the CBSG for NDMA in bedrock groundwater. A TI waiver for the CBSG for NDMA in bedrock groundwater is being invoked in this ROD. To comply with ARARs, the groundwater RAOs are based upon reducing the COC concentrations to levels at or below MCLs and/or CBSGs.

Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness or permanent remedy for the groundwater contamination. Since Alternative 1 fails to meet both threshold criteria, it is not discussed further in this analysis.

Alternative 2 will achieve long-term effectiveness for the groundwater COC, TCE, and its daughter products through a non-reversible process of biodegradation with no waste products or residuals. The Restrictive Notice which prevents use or contact with groundwater contaminated with the PJKS groundwater COCs (TCE and its daughter products and NDMA) will exist until unrestricted use and unlimited exposure concentrations are met and will be monitored and enforced by CDPHE.

Reviews at least every five years, as required, would be necessary to evaluate the effectiveness of either of these alternatives because hazardous substances would remain on-site in concentrations above health-based levels.

Reduction of Toxicity, Mobility, or Volume

Alternative 2 uses in-situ biodegradation to irreversibly reduce the toxicity and volume of groundwater contaminated by the groundwater COC, TCE, and its daughter products. The in-situ bioremediation system relies upon anaerobic reductive dechlorination to accelerate degradation of TCE and associated contaminants to irreversibly reduce the toxicity and volume of the contaminants until finally only ethane, which is relatively non-toxic, remains. Based on several decades of groundwater monitoring data, the groundwater plumes have proven to be stable and do not show indication of expansion or increase in toxicity. Mobility of TCE and NDMA in groundwater is not expected to be affected by the remedy.

Short-Term Effectiveness

Alternative 2 is protective of the community and workers because it implements LUCs which prevent worker exposure to contaminated groundwater immediately and decreases concentrations of TCE and its daughter products in source areas contributing to the groundwater contamination.

If additional wells need to be installed in order to expand the monitoring well or injection well network, there would be a slight increase to environmental impacts and worker risks from well installation.

Implementability

Alternative 2 is readily implementable. The existing network of wells installed for studies or for interim measures is expected to allow full implementation of the remedy. The existing well network should not require any additional components based on current conditions. Changes in conditions may require some additional injection or monitoring wells. No other modifications or extra infrastructure is anticipated to operate the full scale system with sustained operations and maintenance.

Cost

The present worth costs for Alternative 2 is $611,000. Costs were developed using the Remedial Action Cost Engineering and Requirements™ (RACER™) software. Capital costs, O&M costs, or present worth costs estimated for Alternative 2 are included in Appendix C.

Capital Cost:	$1,067,353
O&M Cost:	$29,333 to 118,351, with typical annual cost of $32,043 (O&M Cost Varies by Year – See Table 11)
Total Present Worth:	$611,000

State Acceptance

The State has expressed its support for Alternative 2. The State does not believe that Alternative 1 provides adequate protection of human health and the environment.

Community Acceptance

During the public comment period for the proposed plan, no comments were submitted by EPA or CDPHE nor were there any public comments submitted during the public meeting. However one written comment was received regarding the long-term water quality impacts to Brush Creek and Chatfield Reservoir. The comment and its response have been included in the Responsiveness Summary, Appendix A.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that the EPA will use treatment to address the principal threats posed by the site wherever practicable (NCP §300.430(a)(1)(iii)(A)). Identification of principal threat wastes combines the concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-principal threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure. The manner in which principal threats are addressed

generally will determine whether the statutory preference for treatment as a principal element is satisfied.

No principal threat wastes were identified at PJKS. The contaminants in soils at PJKS bind to soils and are low-mobility. Contaminants from the soil SWMUs have not been found in the groundwater underlying those SWMUs. The highest concentrations from these contaminants do not pose risks greater than several orders magnitude above the risk range and can be reliably contained. Contaminated groundwater is not a principal threat waste in itself, but can contain LNAPLs or DNAPLs, which may constitute a concentrated and mobile source for contaminants in groundwater. These can occur as floating layers (LNAPL) or sinking layers (DNAPL). Neither form of non-aqueous phase liquids has been found as a discrete layer or as residuals.

2.12 SELECTED REMEDY

Based upon consideration of the requirements for RCRA, CERCLA, the NCP criteria and public comments, the following is the selected remedy for the four (4) soil OUs that encompass the 53 soil SWMUs:

The response actions for soil OUs/SWMUs have been completed as RCRA ICMs and have achieved regulator and community acceptance as the selected remedy for soils under public comment on the various reports associated with the ICMs or Interim Removal Actions.). The RAOs for soil SWMUs are:

- Excavation and proper off—site disposal of contaminated soils where practicable. Most of these areas have been excavated to meet residential standards.

- Prevent exposure to soils above industrial standards through engineering and/or institutional controls (See Also Table 4).

The selected site remedy for the 53 soil SWMUs fall into three categories (**Table 2**):

1. Closure to unlimited use/unrestricted exposure levels where the concentration of all potential COCs in soil are below their corresponding unlimited use/unrestricted exposure levels for soil as approved by EPA and CDPHE (see discussion below),
2. Restricted Closure with LUCs where the concentration of all potential COCs in soil are below approved safe for industrial use levels but do not allow unrestricted use, or
3. Restricted Closure with LUC and limited cover where COCs remain in soil at concentrations above levels considered safe for industrial use because removal was not possible.

Figure 13 illustrates the locations of the soil SWMUs with restricted closure.

Criteria to achieve RAOs for soil are based on CDPHE's Tier 2 SRO values (CDPHE, 2003), and were established specifically for PJKS. They were developed using guidance from the Proposed Soil Remediation Objectives Policy Document (State of Colorado, 1997). Review of the SRI for PJKS showed that the actual concentration of a large majority of the individual chemical constituents analyzed in the PJKS soil were below their respective industrial scenario SROs. The SROs are human health risk-based concentrations applied to possible land uses, which for PJKS were assumed to be industrial or commercial. However, a set of SROs for unlimited use/unrestricted use (i.e., residential) were developed in the event that soil data showed that this criteria could be met after the ICMs/interim remedial actions were complete.

The quit claim deed transferring PJKS from the USAF to Lockheed Martin restricts the current and future use of the entire former PJKS to non-residential (Section V.C.I). As a result, Tier 2 SRO values were calculated based on the risk to human health using an industrial land use scenario, which provides more conservative values than the commercial land use scenario. The Tier 2 SRO values were approved by CDPHE and EPA (CDPHE, 2003) and are summarized in the *CSI Report* (Shaw, 2005b).

The Tier 2 STG values for PJKS were also calculated to ensure that the CBSGs (State of Colorado Regulation 41, Title 5 CCR 1002-41) would be not exceeded due to presence of residual soil contamination. The PJKS values were calculated using PJKS site-specific model input parameters, rather than using concentrations that have been calculated using guidelines and assumptions established for a generic Colorado site. Because the Tier 2 Industrial SROs are, in general, more conservative (i.e., lower values) than the Tier 2 STG values, the Tier 2 Industrial SROs were used for the RAOs. The Industrial SRO values that were used as the criteria for determining whether the ICM activities were able to achieve the PJKS soil RAOs are presented in **Table 4**.

As noted in categories 2 and 3 above and in Table 2, there are portions of PJKS where closure of soil sites to unlimited use/unrestricted exposure levels was not achieved. These areas have monitoring and maintenance and/or use restrictions associated with them. **Table 10** presents the remedial action activities required to achieve the PJKS RAOs for those soil SWMUs where the Residential SROs were not met. To mitigate the risks and exposure to these limited areas the monitoring and maintenance requirements necessary to ensure the continued protectiveness of the remedy have been incorporated into the Operations and Maintenance Plan, CSA-3, T8A Surface Impoundment, Combined Soils Units SWMUs 12, 29, 31 (Shaw, 2010a) with annual site visits to check on the integrity of the covers and maintenance as required.

This ROD formalizes the requirement for the LUCs and continued operation and maintenance to consider the soil remedies final under CERCLA. The implementation of the operation and maintenance activities for the soil SWMU remedies will be enforced under PJKS Order on

Consent and the PJKS Restrictive Notice. Reports for the remedies for soil can be found in the AR. These soil sites are addressed in this ROD to document their completion as part of the final remedy for the site.

Any determination by the USAF, in consultation with LMSSC, CDPHE and EPA, to pursue unlimited use / unrestricted exposure in the future at restricted soil SWMUs will be documented in a separate decision document, as either an addendum or an ESD to this ROD.

SELECTED REMEDY FOR GROUNDWATER

Based upon consideration of the requirements for RCRA, CERCLA, and the NCP criteria, the detailed analysis of alternatives, and public comments, the following alternative was determined to be the appropriate remedy for groundwater at PJKS:

- Groundwater SWMUs 1, 2, and 3 – In-situ Bioremediation with Restrictive Notice (Alternative 2)

This selected remedy for groundwater will be protective of human health and the environment, comply with ARARs, except were a waiver is granted, and will meet the RAOs described in Section 2.8.

Implementation of the Selected Final Remedy

All active remedial construction work required for the selected final remedy for soil SWMUs is complete. The LUCs and continued operation and maintenance requirements for soil SWMUs formalized in this ROD will be implemented via the PJKS Restrictive Notice as described below. The PJKS Order on Consent also provides an enforceable regulatory mechanism for the continued implementation of operation and maintenance requirements for soil SWMUs.

All of the infrastructure necessary to implement the selected final remedy for groundwater SWMUs has already been constructed and is fully operational at PJKS. No additional components, modifications or extra infrastructure will be required to implement the selected final remedy for groundwater. The selected final remedy for groundwater SWMUs has been, and will continue to be operated in accordance with the *Implementation Work Plan Groundwater Source Areas Interim Corrective Measure* (Shaw, 2007c) and the *Implementation Work Plan Addendum Groundwater Source Areas Interim Corrective Measure* (Shaw, 2008a) until a new Operations and Maintenance Plan described below is approved by EPA and CDPHE. The LUCs and continued operation and maintenance requirements for groundwater SWMUs formalized in this ROD will be implemented via the PJKS Restrictive Notice.

The continued performance of operation and maintenance activities necessary to ensure the continued protectiveness of the selected final remedy for soil SWMUs and groundwater

SWMUs is also a specific requirement of the PJKS Order on Consent under the Colorado Hazardous Waste Act and Regulations. The *Operations and Maintenance Plan, CSA-3, T8A Surface Impoundment, Combined Soils Units SWMUs 12, 29, 31* (Shaw, 2010a) has already been approved under the PJKS Order on Consent and operations and maintenance will continue to be performed in accordance with this ROD.

Summary of the Rationale for the Selected Final Remedy

The soil SWMUs were addressed as interim measures/interim actions principally through the RCRA corrective action process with EPA involvement throughout the process. These remedies are of the same type which would be considered under CERCLA and the NCP. The soil remedies are considered protective, comply with requirements which are applicable or relevant and appropriate, and represent the best balance of trade-offs among the balancing criteria. Where it was feasible to excavate the soil SWMUs, residential standards rather than industrial were achieved at most locations because the cost increases were incremental and eliminated long-term O&M costs at these SWMUs resulting in greater long-term effectiveness. For SWMUs which could not be excavated without interfering with structures or ongoing operations, the best balance of tradeoffs among implementability, effectiveness, and cost relied on Land Use Controls (LUCs) and/or physical containment under asphalt caps (parking areas) to prevent exposure. The Air Force may elect in the future to address some of these SWMUs by excavation for simpler long-term management. Because the soil remedies meet the statutory requirements of CERCLA and attain the same standards as would be required under CERCLA, no further analysis will be done to consider them final remedies in this ROD.

In-situ bioremediation with Restrictive Notice is selected for the remediation of TCE-contaminated groundwater. A TI waiver with Restrictive Notice was selected for NDMA in contaminated bedrock groundwater. In-situ bioremediation with Restrictive Notice (Alternative 2) was chosen because it meets the threshold criteria of providing overall protection of human health and the environment and, with the waiver to achieve the CBSG for NDMA in contaminated bedrock groundwater in a reasonable timeframe, is expected to comply with ARARs. The selected alternative provides the best balance of trade-offs among the balancing and modifying criteria. The key criteria are long- and short-term effectiveness, implementability, and cost. The remedy provides long-term effectiveness because the plumes are stable and contained on site and the TCE and associated contaminants are irreversibly degraded into non-toxic products or residuals, currently estimated to take approximately 10-20 years. This also reduces the toxicity and volume of contaminants, although there is some uncertainty in whether NDMA in the alluvium will degrade to the CBSG. Short-term effectiveness concerns are minimal, with a slight increase to worker risk and environmental impacts if more wells are installed. The alternative is readily implementable and it is believed the existing network of injection and monitoring wells is usable to bring the remedy to full

scale operation. Costs are reasonable for a treatment alternative of this size and much lower than ex-situ treatment alternatives. CDPHE and EPA support Alternative 2. The only comment from the community did not relate directly to the remedy and did not oppose the remedy.

In-situ bioremediation has already been implemented at the site as part of ICMs. Performance monitoring results indicate that the in-situ bioremediation is successfully treating TCE and daughter products within the groundwater source areas. As noted above, the Air Force will continue to operate and monitor the existing bioremediation system at the PJKS via the PJKS Order on Consent and PJKS Restrictive Notice. In-situ bioremediation is protective of human health and the environment, complies with ARARs, reduces contaminant mobility, is cost effective, and is expected to meet RAOs. In addition, the selected remedy satisfies the statutory preference for treatment as a principal element of the final remedy through treatment of TCE-contaminated groundwater. The USAF has determined that the selected remedy represents the maximum practicable extent to which permanent solutions can be used in a cost-effective manner for PJKS.

Description of the Selected Final Remedy For Groundwater

The selected remedy for contaminated groundwater is to continue the currently approved Interim Corrective Measure in-situ bioremediation at PJKS. In-situ biodegradation of TCE has been proven effective at PJKS. Results of previous pilot studies and ICMs conducted at PJKS indicate that sodium lactate, emulsified vegetable oil or equivalent are effective substrates for enhancing the biodegradation of TCE at this site. Currently, ICMs are in place at all seven groundwater source areas and in the biobarriers in the distal portion of the plumes. For the final groundwater remedy, in-situ bioremediation will continue to be stimulated in the Fountain Formation and Precambrian aquifers at these source areas by injecting sodium lactate or emulsified vegetable oil and a bioaugmentation culture (DHC) as needed in specific wells in these areas. The decisions related to if and when injections are required will be made in accordance with the *Implementation Work Plan Groundwater Source Areas Interim Corrective Measure* (Shaw, 2007c) and the *Implementation Work Plan Addendum Groundwater Source Areas Interim Corrective Measure* (Shaw, 2008a) until the new Operations and Maintenance/Long-term Monitoring Plan for SWMU 1, SWMU 2 and SWMU 3 is approved.

Figure 14 shows the location of the specific monitoring wells (some used as vertical injection wells), direction and vertical injection wells, performance monitoring wells and biobarrier locations that constitute the initial selected final remedy for groundwater SWMUs. A bioaugmentation culture (DHC) can also be added to enhance biodegradation in a given media. The microbes that are being injected were initially collected from the successful D-1 Pilot Study location. Those microbes were cultured in the laboratory to increase the mass of

microbes. The microbes are pumped below the water table (approximately 5 to 10 gallons) for each applicable injection well.

Technical Impracticability Waiver

Under the provisions defined in CERCLA §121(d)(4)(C) and RCRA Sections 264.525(d)(2) and 264.531 of the Proposed Subpart S rule, in the event that an ARAR(s) or MCS cannot be achieved, based on limiting site characteristics or engineering impracticability, one or more ARARs may be waived (EPA 1993). A TI evaluation was completed for PJKS for NDMA in bedrock groundwater. The USAF submitted the "Technical Impracticability Waiver Report for Former USAF Plant PJKS" (Shaw 2011a) in October 2011. EPA and CDPHE agreed with the USAF's analysis that neither in-situ bioremediation nor any other groundwater treatment technology was a technically practicable remedy for NDMA in PJKS bedrock groundwater. The waiver is justified based on a combination of a very large volume of NDMA contaminated bedrock groundwater, poor permeability of the bedrock (i.e., pumpability), inability to access all of the contaminated groundwater due to fractured bedrock with unpredictable flow characteristics, and associated matrix back diffusion. The TI Waiver does not apply to NDMA contaminated alluvial groundwater at PJKS. However, it is understood NDMA in the alluvial aquifer responds slowly and inconsistently to the in-situ treatments in the alluvial aquifer, and the remedy may need to be re-evaluated during the 5 Year Reviews.

The horizontal extent of the TI Waiver for PJKS bedrock groundwater (the TI Zone) is defined by the extent of the bedrock NDMA contaminant plume and is depicted with dashed blue lines on **Figure 2**. The vertical extent of the TI Zone is defined as the lower-most bedrock aquifer in which NDMA contamination exceeding CBSGs has been detected. In the Fountain Formation bedrock, NDMA contamination extends to a depth of approximately 135 feet below the ground surface. In the Precambrian bedrock, the NDMA contamination extends to approximately 100 feet bgs.

The elements of the selected final remedy include the following:

- Continuation of the treatment studies in groundwater which includes monitoring and substrate injections (if required);
- Monitoring for remedy performance and to verify plume stability; and
- Administering a Restrictive Notice, including restricting land use to industrial use only, site access control, and recording the restrictions in the Lockheed Martin 'black zone' map.

Restrictive Notices for Both Soil and Groundwater

The Restrictive Notice portion of the selected remedy for both the soil and groundwater SWMUs will be accomplished pursuant to the Colorado Environmental Covenant Act, Sections 25-15-317 through 322 of the Colorado Revised Statutes. Restrictive Notices are legal documents issued by CDPHE at the request of a property owner (Lockheed Martin) that specify all of the restrictions on the land use or the groundwater beneath the land and/or maintenance of engineering controls on a property where the environmental cleanup has not achieved unlimited use/unrestricted exposure levels. Restrictive Notices are attached to the deed of a property and remain enforceable in perpetuity by CDPHE against all future property owners and users.

Lockheed Martin, as the owner of the property, has agreed to allow CDPHE place the restrictions specified in the Restrictive Notice on their property while the USAF retains responsibility for ensuring continued compliance with the restrictions and monitoring and maintenance requirements specified in the environmental covenant as long as the restrictions remain on the deed. The USAF shall also retain ultimate responsibility for the environmental covenant restrictions and requirements in the event that the USAF transfers procedural responsibility to another party by contract or other means.

The USAF shall not modify or terminate LUCs, implementation actions, or modify land use without approval by EPA and CDPHE. The USAF shall seek prior concurrence before any anticipated action that may disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.

Lockheed Martin has agreed to the industrial use cleanup level for the site (included in the quit claim deed) and has committed to placing a Restrictive Notice on the PJKS property (the PJKS Restrictive Notice). The Restrictive Notice will specify that all of the property that comprises PJKS will only be used for industrial purposes. Specifically, the prohibited uses of the property include, but are not limited to, childcare, elder care, pre-school(s), school(s), playground(s), health care facilities, or any form of residential housing.

Out of the 53 soil SWMUs investigated and evaluated at PJKS, only 16 of the soil related SWMUs actually require a Restrictive Notice to restrict use of the land to industrial only. Only 4 of the 16 SWMUs and one small non-SWMU actually require long-term maintenance of engineering controls to protect worker health. However, Lockheed Martin has determined that a non-residential land use restriction will be applied to the entire property that encompasses PJKS for ease of implementation of the Restrictive Notice.

In addition to the prohibition against future residential use of the property, the PJKS Restrictive Notice will also require inspection and maintenance of concrete or asphalt covers for soil SWMUs that rely on engineering controls as the selected remedy. The PJKS Restrictive Notice will also include prohibitions against disturbance, by the current and future property owners and operators, of the cover or underlying soil for portions of soil SWMUs that rely on covers. This will be accomplished via an internal Lockheed Martin work permitting program known as a Dig Permit. Every employee or contractor who wishes to conduct an excavation of any kind on the Lockheed Martin property (which now includes all of the former PJKS property) must apply for, and obtain, a Dig Permit from the Lockheed Martin Facilities Program. Each permit application is reviewed by personnel from the LMSSC Environmental, Safety and Health (ESH) Department to ensure the excavation is not planned for an area with known soil contamination. The personnel from the Environmental Program consult what is known as the "Black Zone Map," which is a large scale map of the entire property showing the location of every known area where precautions must be taken to ensure protection of the excavation personnel. The ESH Department then documents the required protective equipment and/or procedures that are required to dig in a specific area and repair/reconstruct the cover to the original remedy specifications.

All three of the groundwater SWMUs investigated and evaluated at PJKS require a Restrictive Notice to restrict groundwater use. The PJKS Restrictive Notice for the restrictive closure soil SWMUs and the three groundwater SWMUs will remain in effect until unlimited use/unrestricted exposure levels are achieved.

The same PJKS Restrictive Notice that has been selected to enforce LUCs for the Soil SWMUs will also be used to prevent human exposure to TCE and NDMA in bedrock and alluvial groundwater in perpetuity, or until unlimited use/unrestricted exposure levels are achieved. With respect to the selected remedy for groundwater SWMUs, the PJKS Restrictive Notice will prohibit future productive use of groundwater throughout the entire former PJKS property and ensure that workers performing excavation actions do not come into contact with contaminated groundwater. This will be accomplished via the same internal LMSSC Dig Permit detailed in the description of the selected remedy for the soil SWMUs. The PJKS Restrictive Notice will be issued on the property by CDPHE at the request of the property owner, Lockheed Martin, and gives CDPHE the right to enforce, in perpetuity, restrictions on the use of the land. Lockheed Martin has determined that the restriction on productive use of groundwater and dig-permit program will be applied to the entire property that encompasses PJKS for ease of implementation of the Restrictive Notice.

The *Operations and Maintenance Plan, CSA-3, T8A Surface Impoundment, Combined Soils Units SWMUs 12, 29, 31* (Shaw, 2010a) and the Operations and Maintenance/Long-term Monitoring Plan for PJKS will be incorporated into the PJKS Restrictive Notice by reference

and citation. The PJKS Restrictive Notice will refer to the latest version of the plans as the plans that must be followed. The USAF will pay for implementation of the PJKS Restrictive Notice and is ultimately responsible for complying with the Restrictive Notice requirements. However, the USAF has contracted with Lockheed Martin to implement the PJKS Restrictive Notice on behalf of the USAF. Under contract to USAF, Lockheed Martin will conduct maintenance of the covers and conduct the annual inspection of the PJKS Site to ensure that the PJKS Restrictive Notice restrictions are being complied with and any problems are resolved.

The PJKS Restrictive Notice will include a prohibition against any current and future property interfering with the effectiveness of the selected remedy components/ monitoring components and prohibition against interfering with the USAF's ability to conduct or maintain, or monitor required remedial actions. In addition to the enforcement role of CDPHE, the U.S. EPA and the USAF will be a third party beneficiary for the PJKS Restrictive Notice and under the Colorado Environmental Law can file suit to stop any party from violating the requirements of the covenant.

Other requirements of the PJKS Restrictive Notice will include a requirement to notify CDPHE and EPA a minimum of 45 days in advance of a proposed land use change that affects any site property with a restricted use and notify EPA and CDPHE a minimum of six months in advance of any proposed grant, transfer or conveyance of any interest in any or all of the PJKS Property. Colorado Restrictive Notices also have specific standard language with the requirements for modifying the Notice restrictions.

Monitoring of the environmental use restrictions and controls will be conducted annually by the USAF. The monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to the EPA and CDPHE. The annual monitoring reports will be used in preparation of the Five Year Review to evaluate the effectiveness of the remedy.

The annual monitoring report, submitted to the regulatory agencies by the USAF, will evaluate the status of the ICs and how any IC deficiencies or inconsistent uses have been addressed. The annual evaluation will address whether the use restrictions and controls referenced above were communicated in the deed(s), whether the owners and state and local agencies were notified of the use restrictions and controls affecting the property, and whether use of the property has conformed to such restrictions and controls.

Since the PJKS Restrictive Notice must document the final LUCs from the final PJKS remedy, it cannot be recorded to the deed of the property until after the PJKS ROD is signed. The PJKS Restrictive Notice will be signed by CDPHE within 90-days of submittal of the PJKS

Construction Completion Report, which is a maximum of 180-days from the date the PJKS ROD is signed.

Land Use Control Notification Requirements Incorporated Directly into the PJKS ROD Selected Final Remedy

U.S. EPA has specific language and notification requirements that are to be incorporated into federal facility RODs when LUCs are employed as part of the selected final remedy. A majority of EPA's required LUC notification language has been incorporated directly into the PJKS Restrictive Notice. However, the notification requirements specified below are not standard components of Colorado Restrictive Notices. Instead, these notification requirements are incorporated into this ROD and will be incorporated into future Operations and Maintenance/Long-term Monitoring Plan(s) and implemented via the PJKS Order on Consent.

These requirements include:

- The USAF or property owner will submit an annual report describing the results of annual inspection of covers which certifies to CDPHE and EPA that the PJKS Restrictive Notice is being complied with.
- The USAF and/or Lockheed Martin will notify CDPHE and EPA within 10-days of discovery that a requirement of the PJKS Covenant has been violated. The USAF and/or Lockheed Martin will notify EPA and CDPHE regarding how the USAF has addressed, or will address, the violation.
- The USAF or Lockheed Martin will notify CDPHE and EPA a minimum of six months in advance of a proposed property transfer and a minimum of 45-days in advance of a proposed land use change that affects any site property with a restricted use.

Summary of the Estimated Final Remedy Costs

This section presents the estimated final remedy cost for the groundwater remedy. The final remedy for the soil is already in-place, therefore, for the purposes of this ROD there is no estimated final remedy cost for soil.

Estimated Final Remedy Cost for Groundwater

Alternative 2, In-Situ Bioremediation, would consist of continuing the ICMs, with modification to the system as necessary to implement the existing measures as a long-term solution. The major components of the alternative are the substrate material and then the means to inject the substrate to groundwater (i.e., via pumps and an appropriate energy source). Groundwater monitoring will continue to evaluate the performance. This alternative also includes costs (in

year 30) for the abandonment of the groundwater monitoring well network (**Figure 15**). **Table 11** presents the cost summary, which is summarized below:

Capital Cost:	$1,067,353
O&M Cost:	$29,333 to 118,351, with typical cost of $32,043 (O&M Cost Varies by Year – See Table 11)
Total Present Worth:	$611,000

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the design or implementation of the remedial alternative. Major changes may be documented in the form of a memorandum in the AR file, an ESD, or a ROD Amendment. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

Expected Outcomes of the Selected Final Groundwater Remedy

The selected final remedy will eliminate future human health risks by reducing TCE levels in groundwater to the CBSGs or achieving asymptotic conditions. This remedy will also eliminate risks by putting a Restrictive Notice on the property to limit exposure pathways of human receptors to 1) contaminated groundwater and 2) contaminated soils. By maintaining the Notice, the selected remedy reduces risks to human health to acceptable levels. The final remedies do not change the current or planned future land use of PJKS.

In-situ bioremediation of TCE is expected to reduce contaminant concentrations to below the CBSGs or to asymptotic conditions within approximately 10-20 years. Carbon substrates and/or DHC injections will continue periodically at the seven groundwater source areas in accordance with the work plans (Shaw 2006b, 2006c, and 2007c). In addition, periodic monitoring of the in-situ bioremediation system will continue per an ongoing optimization evaluation. Use of the bedrock groundwater in the area will remain restricted in perpetuity because in-situ bioremediation is not expected to reduce NDMA levels to below the CBSGs in a reasonable timeframe. The TI waiver was invoked regarding the CBSG for NDMA in bedrock groundwater source areas, so a Restrictive Notice will be used to restrict the use of groundwater from these areas.

Concentrations of soil contaminants from 4 SWMUs remaining in place are protective under an industrial use scenario only if the limited covers are maintained. Concentrations of soil contaminants from 12 SWMUs remaining in place are protected under an industrial use scenario, but are not suitable for residential use. There is no additional active remediation of soils intended for PJKS; therefore, the Restrictive Notice will remain on the property indefinitely to restrict the area to industrial use.

Implementation of the selected groundwater remedial actions for TCE in bedrock source areas will continue until the concentration of TCE and its daughter products in the bedrock groundwater source areas either meet CBSGs, or until adequate data is available to demonstrate that the further reduction in the concentration of TCE in bedrock groundwater source areas is not feasible. One of the ways this can be done is to show that TCE concentrations in groundwater at one or more of the bedrock source areas have reached asymptotic levels. This asymptotic concentration will be considered a shut-off criterion for active bedrock source area treatment activities. The shut-off criteria will be considered met when one of two conditions is achieved:

1. The concentration of TCE and its daughter products meet CBSGs in groundwater, or
2. Continued treatment will not result in further reductions in TCE in the bedrock groundwater in a particular source area. This is generally agreed to be the time when TCE concentrations in bedrock groundwater over time reach an asymptotic concentration. The asymptotic conditions will be proved and graphed using groundwater monitoring performance data. Achievement of this asymptotic criteria may show source area degradation at the point where it is no longer feasible or practicable to continue treatment. Under these conditions the remedy may need to be reviewed.

2.13 STATUTORY DETERMINATIONS

Under CERCLA Section 121, the selected remedy must be protective of human health and the environment, comply with ARARs, and be cost effective. The remedy must also use permanent solutions, alternative treatment technologies, or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that include treatment which will permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances as a principal element.

The following section summarizes the estimated effectiveness of the selected remedies.

Protection of Human Health and the Environment

The selected remedy for the soil SWMUs prevents risks to human health and the environment by maintaining the existing covers over the residual contamination and implementing LUCs to prohibit exposure to soils from unauthorized disturbance to soils.

The selected remedy for groundwater prevents risks presented by the site to human health and the environment by treating the groundwater source areas and limiting access to the lateral footprint of the plumes with the implementation of a Restrictive Notice on the property and adjacent property.

Compliance with ARARs

The amended selected remedies for PJKS will comply with all ARARs (**Table 12**), except where a waiver is approved.

Cost-Effectiveness

Section 300.430(f)(ii)(D) of the NCP requires evaluation of cost effectiveness. The amended selected remedies are proportionally cost effective in mitigating the principal risks posed by contaminated soil, sediment, groundwater, and surface water. The remedy in general is considered effective overall. Alternative 2 is the lowest cost alternative which is also overall protective of human health and the environment and which will comply with ARARs (with the justified waiver). TCE and its degradation products are the dominant chemicals of concern and are expected to be irreversibly converted to non-toxic products, which reduces the toxicity and volume of groundwater. These goals are estimated to be achievable in a relatively short time frame of approximately 10-20 years. There will be no residual wastes to manage. NDMA is a difficult to treat contaminant regardless of whether an in-situ or ex-situ treatment is utilized. Using pumping and ex-situ treatment to address NDMA would substantially increase costs. The costs associated with Land Use Controls (the Notice) would be similar among alternatives to address groundwater and present only an incremental increase in cost. The costs of this remedy are much lower than a pump and treat system for a similar plume, which would likely require much more time and would have much greater O&M costs, by at least an order of magnitude, with similar expected outcomes.

Utilization of Permanent Solutions and Alternative Treatment Technologies (or Resource Recovery Technologies) to the Maximum Extent Practicable

This remedy provides the best balance of trade-offs among the alternatives analyzed. Alternative 2 is the lowest cost alternative which is also overall protective of human health and the environment and which will comply with ARARs (with the justified waiver). The key criteria are long-term and short-term effectiveness, implementability, and cost. The remedy provides long-term effectiveness because the plumes are stable and contained on site and the TCE and associated contaminants are irreversibly degraded into non-toxic products or residuals, currently estimated to take approximately 10-20 years. The selected remedy satisfies the preference for treatment. Land use controls provide an added layer of protection and are readily implementable with an incremental increase in cost. In-situ bioremediation also reduces the toxicity and volume of contaminants, although there is some uncertainty in whether NDMA in the alluvium will degrade to the CBSG. As a result of numerous treatability studies and interim actions, the network of injection and monitoring wells is sufficient to implement the remedy full-scale making the remedy quickly and easily implementable. If additional wells are needed, the installation is easily implementable with incremental cost increases. The CERCLA

bias against off-site disposal is satisfied because no waste streams are produced which need to be managed.

Preference for Treatment as a Principal Element

The selected remedies for PJKS groundwater satisfy the statutory preference for treatment as a principal element by use of active treatment methods. By reducing concentrations of the COCs in groundwater, the principal threats which may be posed by future exposure or ingestion are addressed.

Five Year Review Requirement

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above level that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to insure that the remedy is, or will be, protective of human health and the environment. The groundwater SWMUs and TI zone will be subject to five year reviews until CBSGs are met. The soil SWMUs which impose restricted use will also be addressed in the five year review.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

There have been no significant changes from the preferred remedies originally presented in the proposed plan.

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3.0 PART 3: RESPONSIVENESS SUMMARY

This Section provides a summary of the comments regarding the Proposed Plan and was completed after the Public Meeting and public review comment period. Additionally, taking into consideration the stakeholder comments, the final Selected Remedies for the three SWMUs (SWMU 1 (SS034), SWMU 2 (SS021), and SWMU 3 (SS022)) are listed.

3.1 STAKEHOLDER COMMENTS AND LEAD AGENCY RESPONSES

No comments from the EPA or CDPHE were submitted during the public comment period. One written comment from the public was submitted during the public comment period from 12 January 2012 to 25 February 2012, included in Appendix A. No oral comments were made during the Public Meeting. A transcript of the public meeting is provided in Appendix D.

Written Comments to the Proposed Plan

During the public comment period from 12 January 2012 to 25 February 2012, one written comment from the general public was received regarding the long-term water quality impacts to Brush Creek and Chatfield Reservoir. The written comment submitted during the public comment period is included in Appendix A.

Written Comment 1 (Chatfield Watershed Authority)

Ms. Julie Vlier, representing the Chatfield Watershed Authority, mentions that it is unclear if the proposed monitoring program ensures protection of the Chatfield watershed and its reservoir. Ms. Vlier also states that the Chatfield Watershed Authority is "concerned that contaminated waters may not have yet reached portions of the Chatfield system. The Authority believes that funding to monitor water quality is necessary to confirm that there indeed are no water quality problems".

USAF Response to Written Comment 1

The USAF understands the Chatfield Watershed Authority's concern. Twenty plus years of PJKS specific monitoring data have shown that groundwater contamination created by PJKS activities has not migrated beyond the boundaries of the LMSSC facility that completely surrounds PJKS. Data support that the PJKS plumes are stable and contamination is not migrating further down gradient from the source areas. The discharge of contaminated groundwater to surface streams does not result in an exceedence of State of Colorado Basic Standards for Surface Water in any surface stream on, or downstream of, PJKS. Thus, there is no threat to the environment via the transfer of contaminants from groundwater to surface water exposure scenario.

The groundwater contamination created by PJKS activities has not migrated beyond the boundaries of the LMSSC facility that completely surrounds PJKS. Further, if for some reasons a plume of PJKS-sourced groundwater contamination were to ever expand in size, it would be moving further onto surrounding Lockheed Martin property. A major component of Lockheed Martin's groundwater remediation program for their own site consists of a series of groundwater interceptor systems. The systems intercept, to the extent practical, all of the contaminated alluvial groundwater before it leaves Lockheed Martin property. The intercepted water is treated to meet State of Colorado surface water standards before being discharged to the South Platte River.

While the Lockheed Martin remediation system was not installed to remediate PJKS sourced groundwater contamination, Lockheed Martin will be required to continue to operate the groundwater remediation system under a State of Colorado Hazardous Waste Corrective Action Order on Consent as groundwater contamination exists on their property; even if the contamination is sourced from PJKS.

In addition, Denver Water also regularly analyzes surface water samples from Chatfield Reservoir and has never detected concentrations of any PJKS contaminant of concern that exceed the State of Colorado Basic Standards for drinking water.

3.2 SELECTED REMEDIES

After careful consideration, the USAF, EPA and CDPHE, with community concurrence, have selected the following final remedies for the three PJKS groundwater SWMUs (SWMU 1 (SS034), SWMU 2 (SS021), and SWMU 3 (SS022):

- Alternative 2 – In-Situ Bioremediation with Restrictive Notices. Alternative 2 is recommended because it provides high levels of overall protection of human health by controlling and restricting access to the site and limiting potential exposure to groundwater.

3.3 TECHNICAL AND LEGAL ISSUES

There are no technical or legal issues associated with the recommendation of the Selected Remedies for OU-4 Site SS022 or OU-5 Sites ST034, and SS021 at the time of this publication.

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Tables

TABLE 1
OU AND SITE NAME SUMMARY

OU	SWMU #	SWMU Name
1	5	Waste Propellant Storage Unit
1	7	Leak Detection Line Drain (BC-79) at T-6033
1	29	Systems and Components General Area (SCA)
1	30	Systems Fuel Vault French Drain (BC-58) at T-6032
1	36	System Oxidizer Tank Vault French Drain (BC-61) at T-6031
1	37	Components Cavitette and Leachfield: T-27
1	38	Systems Cavitette and Leachfield: T-28
1	43	T-28D Equipment Room Floor Drain
2	6	Decontamination Trailer Tank Spill Area
2	10	Upper (LOX) Volcano
2	11	Lower (Fuel) Volcano
2	12	Valve Shop Solvent Storage Area
2	13	Valve Shop Process Water Drain
2	28	Riprap Area West of Central Support Building T-17
2	31	Engineering Propulsion Laboratory (EPL) General Area
2	32	Valve Shop Acid Tank Area
2	39	T-6 Blockhouse Cavitette and Leachfield
2	42	T-20A Compressor House
2	44	Central Support Area: T-17
2	45	Pump Pit #2
2	47	Tank MM7, Building T-23
2	49	Tank MM4, Building T-6
3	8	T-8A Surface Impoundment
3	9	D-1 Landfill
3	14	T-31 Chemical Treatment Facility
3	15	T-8 Drainage Flumes
3	16	D-1 Test Stand
3	17	D-2 Test Stand
3	18	D-1 Fuel Storage Area
3	19	D-2 Fuel Storage Area
3	20	Acid Neutralization Pit
3	21	D-3 Test Stand
3	22	D-4 Test Stand

TABLE 1
OU AND SITE NAME SUMMARY

OU	SWMU #	SWMU Name
3	23	T-9 Gas Storage Area
3	24	D-4 Fuel Storage Area
3	25	D-3 Fuel Holding Pond
3	26	D-4 Fuel Holding Pond
3	27	Riprap Area North of T-8A Containment Pond
3	34	T-13A Deluge Tank Area
3	35	D-1 Septic Tank and Leach Field
3	48	Tank 005, Building T-A
3	50	Tank MM6, Building T-A
3	51	Tank MM8, Building T-B
3	52	Tank MM9
3	53	Tank MM11, Building T2-A
3	54	Tank MM12, Building T2-B
3	55	Tank MM13, Test Stand D-3
3	56	Tank MM14, Test Stand D-4
4	3	Lariat Gulch Groundwater Plume
5	1	East Fork Brush Creek (EFBC) Groundwater Plume
5	2	West Fork Brush Creek Groundwater Plume
6	4	Open Burning/Open Detonation Unit
6	33	Ordnance-Testing Laboratory Oil Leak Area
6	40	Field and Central Support Septic Tank and Leachfield: T-17 and T-23
6	41	Ordnance Testing Lab Cavitette and Leachfield: T-26
6	46	Missile Storage Building Drain: T-42

TABLE 2
SOIL SWMU FINAL REMEDIES

SWMU	Final Selected Remedy
4, 5, 6, 7, 9, 10, 11, 14, 18, 23, 26, 27, 28, 30, 32, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, and 56	Unlimited Use / Unrestricted Exposure
13, 15, 16, 17, 19, 20, 21, 22, 24, 25, 33, and 34	Restricted Closure with Land Use Controls
8, 12, 29, 31, and CSA-3	Restricted Closures with Land Use Controls and Limited Covers

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TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
1984 (JRB 1984)	Installation Restoration program Phase I – Records Search, Final, Air Force Plant PJKS	Preliminary assessment of the PJKS facility.	SWMU 8, 9, 12, 13, 14, 29, 31, 42	In 1984, the Installation Restoration Program (IRP) preliminary assessment/records search for PJKS identified sites for further investigation.
1985 and 1986 (ES 1986)	Installation Restoration Program, Phase II – Confirmation/Quantification (Stage I) for Air Force Plant PJKS	Determine the presence or absence of contamination at the sites identified during the Phase I.	SWMU 1, 8, 9, 12, 13, 14, 27, 29, 30, 31, 32, 42	An IRP Phase II, Stage 1 confirmation/quantification investigation was conducted in 1985 and 1986. The study confirmed the presence of contamination at the sites and identified specific requirements for additional work needed.
1987 and 1988 (ES 1988 and 1989)	Installation Restoration Program, Phases II and IVA (Stage 2), Draft Final Remedial Investigation for Air Force Plant PJKS and Installation Restoration Program, Phases II and IVA (Stage 2), Draft Final Supplemental Report for Air Force Plant PJKS	Determine the presence or absence of contamination at IRP sites.	SWMU 1, 2, 6, 7, 8, 9, 12, 13, 14, 25, 27, 29, 30, 31, 32, 33, 36, 41, 42, 43, 44, 45, 46, 49	This comprehensive IRP study, including additional Phase II work, was scoped as an remedial investigation/feasibility study (RI/FS) and work was conducted in 1987 and 1988. The study helped to determine the presence or absence of contamination at PJKS.
1992 (Parsons ES 1996)	Supplemental Remedial Investigation/Feasibility Study Informal Technical Information Reports for Operable Units (OUs) 1, 4, and 6	Investigation of 3 OUs to fill data gaps identified during earlier studies.	SWMU 3, 4, 29, 30, 33, 36, 37, 38, 41	During the 1990s, a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS was conducted for 9 of the SWMUs at PJKS to fill data gaps identified during the earlier studies.
1993 (Parsons ES 1995)	Supplemental Preliminary Assessment/Site Inspection, Areas of Concern 1, 2, 3, 4, 5, and 6	Investigation of 4 SWMUs to determine presence or absence of contamination.	SWMU 2, 14, 17. 34	A PA/SI was conducted for 6 Areas of Concern that are represented in 4 SWMUs at PJKS to identify presence or absence of contamination.
1992 through 1996 (Parsons 1998 and 1999)	Installation Restoration Program Supplemental Remedial Investigation Report for Air Force Plant PJKS	Remedial investigation of 37 IRP/SWMU sites in OUs 1 through 6.	SWMU 1 through 36, and 41	A comprehensive Supplemental RI (SRI) report was completed in May 1999. After reviewing the SRI Report, Colorado Department of Public Health and the Environment (CDPHE) identified 20 SWMUs that required additional soil characterization to address remaining data gaps.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
1999 (Stone and Webster 1999)	Engineering Evaluation/Cost Analysis, Operable Unit 5 – East Fork Brush Creek, Former Air Force Plant PJKS	Evaluate five potential remedies for trichloroethene (TCE) and n-nitrosodimethylamine (NDMA) contamination in East Fork Brush Creek.	SWMU 1	The Engineering Evaluation/Cost Analysis (EE/CA) was completed in October 1999 and evaluated five alternatives (No Action, Natural Attenuation with Institutional Controls, In Situ Zero-Valence Iron System, Remote Pump and Treat, and Onsite Pump and Treat) for remediation of TCE and NDMA in groundwater. The recommended alternative was In Situ Zero-Valence Iron System.
2000 (Stone and Webster 2000)	Engineering Evaluation/Cost Analysis, Operable Unit 2 – Upper and Lower Volcano Areas, Former Air Force Plant PJKS	Evaluate four potential remedies for the Upper and Lower Volcano Areas.	SWMU 10 and 11	The EE/CA was completed in September 2000 and to evaluate four alternatives (No Action, Excavation and Offsite Disposal, Onsite Treatment of Soils by Thermal Desorption, and Onsite Treatment of Soils by Solvent Extraction) for remediation of soils. The selected remedy was Excavation and Offsite Disposal.
2000 and 2001 (Stone and Webster 2001)	Construction Completion Report, Early Action Phases I and II, Operable Unit 2 – Upper and Lower Volcano Areas, Former Air Force Plant PJKS	Document the early action activities completed for SWMU 10 and 11.	SWMU 10 and 11	In 2000 and 2001, an early action was performed at the Upper and Lower Volcano Areas. Phase I was completed in November 2000. Phase II was completed in March 2001. Approximately 2,351 cubic yards (cy) of polychlorinated biphenyls (PCB), pesticide, and metals-contaminated soils were removed from these areas. The construction complete report was completed in July 2001.
2001 (Stone and Webster 2001)	Addendum to the Construction Completion Report, Early Action Phase III, Operable Unit 2 – Lower Volcano Area, Former Air Force Plant PJKS	Document the early action activities completed for SWMU 10 and 11.	SWMU 10 and 11	In 2001, a continuation of the Phase I and II early action was performed at the Lower Volcano Area. Phase III was completed in August 2001. Approximately 2,308 cy of contaminated soils were removed from these areas. The construction complete report was completed in September 2001.
2002 (Stone and Webster 2002)	Additional Investigation Report, OU4 – Lariat Gulch Groundwater Plume, Former Air Force Plant PJKS	Additional investigation of the Lariat Gulch Groundwater Plume.	SWMU 3	The additional investigation of SWMU 3, Lariat Gulch Groundwater Plume, was completed in May 2002, helped determine the groundwater contamination and also define nature and extent of soil contamination.
2002 (Arcadis 2002)	RCRA Facility Investigation Solid Waste Management Unit Group I	RFI to investigate SWMUs in Group I	SWMU 51 and 53	The investigations for the 2 SWMUs was completed in 2002 and determined nature and extent of soil contamination. NFA is warranted for the soils SWMUs.
2002 (Arcadis 2003)	RCRA Facility Investigation Solid Waste Management Unit Group H	RFI to investigate SWMUs in Group H	SWMU 42 and 47	The investigation for the 2 SWMUs was completed in 2002 and determined nature and extent of soil contamination. NFA is warranted for the soils SWMUs.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
2003 (Shaw 2003)	Supplemental Remedial Investigation Addendum, OU5 – Brush Creek Groundwater Plume, Former Air Force Plant PJKS	Additional evaluation of the East Fork and West Fork Brush Creek Groundwater Plumes.	SWMU 1 and 2	The re-evaluation of remedial investigation results from SWMU 1 and 2, East Fork Brush Creek and West Fork Brush Creek Groundwater Plumes, completed in July 2003, helped determine the location of the groundwater contaminant source areas and the lateral extent of the groundwater contaminant plumes.
2003 (Arcadis 2003)	RCRA Facility Investigation Solid Waste Management Unit Group G	RFI to investigate SWMUs in Group G	SWMU 37 through 41	The investigation for the 5 SWMUs was completed in 2003 and determined nature and extent of soil contamination. NFA is warranted for the soils SWMUs.
2003 (Shaw 2003)	Evaluation of Alternatives, D-1 Landfill and T-31 Chemical Treatment Facility, Former Air Force Plant PJKS	Evaluate two potential remedies for the D-1 Landfill and the T-31 Chemical Treatment Facility.	SWMU 9 and 14	In September 2003, an Evaluation of Alternatives report was prepared to evaluate two potential remedies for the D-1 Landfill and the T-31 Chemical Treatment Facility. The two potential remedies (Excavation and Offsite Disposal and Installation of a Landfill Cover System) were determined to be technically feasible based on the additional investigation results. Based on the evaluation, Excavation and Offsite Disposal was selected as the most effective and preferred alternative.
2003 (Shaw 2003)	Additional Investigation Report, Systems and Components Areas, Former Air Force Plant PJKS	Present the results of field activities completed to collect data to address regulatory concerns.	SWMU 29, 30, and 36	The report was completed in December 2003 to document field activities for collection of data necessary to characterize and delineate soil contamination. The additional investigation also addressed the specific regulatory concerns provided in comments by CDPHE on the PJKS SRI Report.
2002 (Shaw 2003)	Additional Investigation Report, D-1 Landfill and T-31 Chemical Treatment Facility, Former Air Force Plant PJKS	Additional investigation of the D-1 Landfill and T-31 Chemical Treatment Facilities to help determine the extent and quantity of waste.	SWMU 9 and 14	The additional investigations in the areas of the D-1 Landfill and T-31 Chemical Treatment Facilities was completed in 2002, identified wastes consisting primarily of paper, plastics, copper wire, food, wood, and some construction debris. During the utility repair activities, a small number of crushed drums were also found and removed.
2005 (Shaw 2005)	2004 Annual Groundwater Monitoring Report, Former Air Force Plant PJKS	Study the distribution and migration of TCE and NDMA in groundwater.	SWMU 1, 2, and 3	Groundwater sampling at PJKS has been conducted semi-annually since 2004 and is designed to refine the understanding of contaminant distribution in the groundwater systems to help select the appropriate remedy or remedies for groundwater treatment and to mitigate contaminant migration.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
2003 through 2006 (Shaw 2007)	Summary and Evaluation Report, Brush Creek/Lariat Gulch Groundwater Plumes Pilot Study, Former Air Force Plant PJKS	Evaluate the effectiveness of anaerobic biodegradation of TCE and NDMA in Precambrian bedrock source areas.	SWMU 1, 2, and 3	The Pilot Study was implemented in 2004 and resulted in the chemical degradation of TCE in groundwater, including the production of all of the byproducts and the end-product, ethene. These results indicate that the source areas for groundwater are amenable to anaerobic bioremediation via in-situ injection techniques. The Pilot Study evaluation of the NDMA anaerobic degradation did not show any evidence of a reduction in groundwater concentrations. Concentrations of NDMA in groundwater remained constant throughout the course of the Pilot Study. The report was completed in August 2007.
2003 through 2004 (Shaw 2005)	Combined Soils Additional Investigation Report, Combined Soils Units, Former Air Force Plant PJKS	Additional evaluation of 20 soil SWMU identified by CDPHE as requiring additional soil characterization to address remaining data gaps.	SWMU 12, 13, 15 through 26, 29, and 31 through 35	The Combined Soils Additional Investigation (CSI) Report was completed in August 2005. The study identified 13 soil SWMUs as not requiring any additional action and seven soil SWMUs (12, 13, 15, 17, 22, 29, and 31) as warranting Interim Corrective Measures (ICMs) because these SWMUs posed an unacceptable risk to human health from exposure to the soil medium.
2005 (Shaw 2005)	Interim Corrective Measures Study, Combined Soils Units, Former Air Force Plant PJKS	Evaluate alternatives for soil remediation in seven SWMUs identified in the CSI Report.	SWMU 12, 13, 15, 17, 22, 29, and 31	This study was completed in August 2005 to evaluate three alternatives (No Action, Limited Cover and Land Use Controls, and Limited Excavation and Offsite Disposal) for remediation of polycyclic aromatic hydrocarbon (PAHs) and PCBs in the seven soil SWMUs identified during the CSI Report. The selected ICM remedies included Limited Excavation, Offsite Disposal, and LUCs for four of the seven SWMUs. The selected ICM remedy for the remaining SWMUs included partial excavation with Limited Cover and LUCs.
2005 (Shaw 2005)	Focused Engineering Evaluation/Cost Analysis, Groundwater Plumes, Interim Corrective Measure, Former Air Force Plant PJKS	Evaluation of alternatives for an ICM for remediation of TCE and NDMA in the groundwater plumes.	SWMU 1, 2 and 3	The focused EE/CA was completed in September 2005 and used a streamlining approach to implement the presumptive remedy at multiple locations at PJKS. The plug-in approach is a method of repetitively implementing a removal action for multiple groundwater source areas that are physically similar and have comparable contaminants. In-situ bioremediation, in the form of ARD, coupled with bioaugmentation where warranted, was recommended as an ICM at the bedrock source areas; D-1, D-4, EPL, SCA, CSSA, OTL, and T-8A.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
2005 (Shaw 2005)	Screening Ecological Risk Assessment for Avian Receptors, FS/CMS for Soils, Former Air Force Plant PJKS	Evaluate the risk to ecological receptors from contaminants of concern (COCs) at PJKS.	SWMU 1 through 3, 9, 12 through 26, 29, and 31 through 35	A screening ecological risk assessment for avian receptors was completed in October 2005 for the PJKS facility and concluded that adequate information exists to determine that the risk to avian receptors in soil/sediment is acceptable and does not warrant action.
2006 (Shaw 2006)	Action Memorandum, Groundwater Plumes, Interim Corrective Measure, Former Air Force Plant PJKS	Action Memorandum (AM) to document the recommendation of bioremediation as an ICM for PJKS groundwater.	SWMU 1, 2, and 3	In March 2008, an AM was prepared to document the proposed ICM activities at the groundwater source areas. Based on the results of the focused EE/CA, in-situ biological treatment (or in-situ brioremediation) was proposed for implementation.
2006 (Shaw 2006)	2005 Annual Groundwater Report, Former Air Force Plant PJKS	Study the distribution and migration of TCE and NDMA in groundwater.	SWMU 1, 2, and 3	Annual groundwater sampling at the 3 SWMUs was conducted semi-annually to evaluate TCE and NDMA in groundwater.
2005 (Shaw 2007)	Interim Corrective Measures Remedial Construction Completion Report, Combined Soils Units, Former Air Force Plant PJKS	Document the ICM activities completed for SWMU 12, 13, 15, 17, 22, 29, and 31.	SWMU 12, 13, 15, 17, 22, 29, and 31	In 2005, 2,915 cy of contaminated soil was excavated from SWMUs 12, 13, 15, 17, 22, 29, and 31. Residual contamination was unable to be removed at SWMUs 12, 29, and 31. Four locations with limited covers were incorporated into an Operations and Maintenance (O&M) Plan for restricted use. The construction complete report was completed in January 2007.
2006 (Shaw 2007)	Interim Corrective Measure, Construction Completion Technical Memorandum for CSA-1, CSA-2, and CSA-6 at D-1 Area, Former Air Force Plant PJKS	Document the limited ICM activities completed for SWMU 9 and 14.	SWMU 9 and 14	In 2006, a limited ICM was performed at contaminated soil areas (CSA)-1, CSA-2, and CSA-6. Approximately 420 cy of contaminated soils were removed from these areas. The construction complete report was completed in January 2007.
2007 (Shaw 2007)	2006 Annual Groundwater Report, Former Air Force Plant PJKS	Study the distribution and migration of TCE and NDMA in groundwater.	SWMU 1, 2, and 3	Annual groundwater sampling at the 3 SWMUs was conducted semi-annually to evaluate TCE and NDMA in groundwater.
2006 (Shaw 2008)	Interim Corrective Measure, Remedial Construction Completion Report, D-1 Area Groundwater Plume, Former Air Force Plant PJKS	Summarize the ICM construction activities at the D-1 Area Groundwater Plume.	SWMU 1 and 2	The report was completed in January 2008 to document the ICM construction activities, which consisted of installing four groundwater injection/monitoring wells in the D-1 area in 2006. Additional work to be completed for the ICM, such as sodium lactate injections and groundwater sampling for performance monitoring is ongoing.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
2006 (Shaw 2008)	Interim Corrective Measure, Remedial Construction Completion Report, D-4 Fuel Storage Area, Former Air Force Plant PJKS	Summarize the ICM well construction activities in the D-4 FSA.	SWMU 1 and 3	The report was completed in January 2008 to document the ICM well construction activities, which consisted of installing nine groundwater injection/monitoring wells in the D-4 FSA in 2006. Additional work to be completed for the ICM, such as sodium lactate injections and groundwater monitoring is on-going.
2006 and 2007 (Shaw 2008)	Groundwater Treatment Studies Report, N-Nitrosodimethylamine with Trichloroethene, Former Air Force Plant PJKS, Waterton, Colorado, Revision 1. Prepared for the Air Force Center for Engineering and the Environment. February 26.	Bench-scale tests and pilot tests completed to identify an effective treatment technology for remediation of NDMA in groundwater.	SWMU 1, 2, and 3	An in-situ bench-scale study was conducted on PJKS groundwater to evaluate the feasibility of using in situ biodegradation for NDMA and TCE treatment. Results of the study indicated that bioremediation of NDMA was not successful; although TCE concentrations were reduced through aerobic and anaerobic treatments. In addition, a bench-scale study was conducted on PJKS groundwater to evaluate the feasibility of using an ex situ nickel catalyst system for NDMA and TCE treatment. The bench-scale study indicated that evaluation of the nickel catalyst technology in a field demonstration was warranted. From April 2006 to January 2007, an ex-situ pilot test was performed. While the nickel catalyst proved effective in treating commingled NDMA and TCE in groundwater, under field conditions, regular maintenance was required to reduce fouling and the presence of dissolved nickel in the effluent was problematic.
2008 (Shaw 2008)	Action Memorandum, Removal Action at Solid Waste Management Units 9 and 14, Former Air Force Plant PJKS	Document the proposed activities at the D-1 Landfill and T-31 Chemical Treatment Facility.	SWMU 9 and 14	In September 2008, an AM was prepared to document the proposed ICM activities at the D-1 Landfill and T-31 Chemical Treatment Facility. Based on the results of the Evaluation of Alternatives, Excavation and Offsite Disposal was proposed for implementation.
2008 (Shaw 2008)	2007 Annual Groundwater Report, Former Air Force Plant PJKS	Study the distribution and migration of TCE and NDMA in groundwater.	SWMU 1, 2, and 3	Annual groundwater sampling at the 3 SWMUs was conducted semi-annually to evaluate TCE and NDMA in groundwater.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs)	Summary of Activity
2006 through 2008 (Shaw 2009)	Interim Corrective Measure Construction Completion Report, Groundwater Source Areas, Former Air Force Plant PJKS	Document the ICM activities at the groundwater source areas.	SWMU 1, 2, and 3	The ICM Construction Completion Report was completed in January 2009 to document the ICM activities at the groundwater source areas. The ICM activities consisted of installing 10 directional injection wells and 12 groundwater injection/monitoring wells for the purpose of stimulating ARD in the Fountain Formation and Precambrian aquifers. ICM activities also included injecting sodium lactate and a bioaugmentation culture in specific wells in the source areas. In addition, the construction of two biobarriers were used to inject a mixture of emulsified edible oil (EEO), water, and *dehalococcoides ethenogenes* (DHC) at the transition point of the Fountain and Alluvial aquifers originating from the SCA and the OTL/T-8A source areas. Quarterly performance monitoring is conducted to evaluate the effectiveness of ARD on TCE in groundwater.
2008 and 2009 (Shaw 2009)	Interim Corrective Measure Construction Completion Report, D-1 Landfill Area, Former Air Force Plant PJKS	Document the ICM activities at the D-1 Landfill and T-31 Chemical Treatment Facility.	SWMU 9 and 14	The ICM Construction Completion Report was completed in August 2009 to document the ICM activities at the D-1 Landfill and T-31 Chemical Treatment Facility. The excavation began in September 2008 and approximately 47,090 cy of non-hazardous waste, 600 cy of Toxic Substance Control Act (TSCA) waste, 306 cy of concrete, and 4,835 tons of scrap iron were removed from the D-1 Landfill and T-31 Chemical Treatment Facility.
2009 (Shaw 2009)	2008 Annual Groundwater Monitoring Report, Former Air Force Plant PJKS	Study the distribution and migration of TCE and NDMA in groundwater.	SWMU 1, 2, and 3	Annual groundwater sampling at the 3 SWMUs was conducted semi-annually to evaluate TCE and NDMA in groundwater.
2010 (Shaw 2010)	Operations and Maintenance Plan, CSA-3, T8A Surface Impoundment, Combined Soils Units, SWMUs 12, 29, 31, Former Air Force Plant PJKS	Defines engineering and institutional controls as well as annual requirements for restricted use sites.	SWMU 8, 12, 29, and 31 and CSA-3.	This plan outlines annual operations and maintenance requirements for restricted use sites at SWMUs 8, 12, 29, 31 and CSA-3. Limited covers are in place at all restricted use sites. Annual inspections to verify no disturbance to the covers at SWMUs 8, 12, 29, and 31. Any excavation activity in the areas has to be permitted and the employee worker hours will be tracked.
2010 (Shaw 2010)	2009 Annual Groundwater Monitoring Report, Former Air Force Plant PJKS	Study the distribution and migration of TCE and NDMA in groundwater.	SWMU 1, 2, and 3	Annual groundwater sampling at the 3 SWMUs was conducted semi-annually to evaluate TCE and NDMA in groundwater.

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

Activity Initiated (Report Issue Date)	Action/Report Title	Primary Focus	Applicable Solid Waste Management Units (SWMUs) included	Summary of Activity
2010 (Shaw 2010)	Focused Feasibility Study, Former Air Force Plant PJKS	Evaluation of alternatives for the final remediation of TCE and NDMA in the groundwater SWMUs. Presentation of the historical soil SWMU decisions that included no further action (NFA) and land use controls (LUCs).	All 56 SWMUs (both groundwater and soil)	This focused feasibility study was completed in June 2010 to evaluate two alternatives (No Action and In-situ Bioremediation and Environmental Covenants) for remediation of TCE in the seven groundwater source areas. The proposed remedy is In-situ Bioremediation and Environmental Covenants. A Technical Impracticability (TI) Waiver evaluation was also presented for NDMA in bedrock groundwater.
2010 (Shaw 2010)	Proposed Plan, Former Air Force Plant PJKS	Document and allow for public comment on the recommendation of In Situ Bioremediation and Environmental Covenants as the final remedy for PJKS groundwater SWMUs and NFA and LUCs for soil SWMUs.	All 56 SWMUs (both groundwater and soil)	.

Notes:
AM = Action Memorandum
ARD = anaerobic reductive dechlorination
CDPHE = Colorado Department of Public Health and the Environment
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CSA = contaminated soil area
CSI = Combined Soils Additional Investigation
cy = cubic yard
DHC = dehalococcoides ethenogenes
EE/CA = Engineering Evaluation/Cost Analysis
EEO = emulsified edible oil
ICM = Interim Corrective Measure
IRP = Installation Restoration Program
LUC = Land Use Control
NDMA = n-nitrosodimethylamine
NFA = no further action
O&M = operations and maintenance
OU = operable unit
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl

TABLE 3
PREVIOUS INVESTIGATIONS AT PJKS

RI/FS = Remedial Investigation/Feasibility Study
ROD = record of decision
SCA = Systems and Components Area
SRI = Supplemental RI
SWMU = solid waste management unit
TCE = trichloroethene
TI = Technical Impracticability
TSCA = Toxic Substances Control Act

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TABLE 4
SOIL AND INDUSTRIAL REMEDIAL OBJECTIVES FOR PJKS
SOIL CONTAMINANTS OF CONCERN

Contaminants of Concern	Remedial Action Objectives (mg/kg)
Total PCBs	0.62
PCB-1016	3.9
PCB-1254	0.62
PCB-1260	0.62

Notes:

CDPHE = Colorado Department of Public Health and Environment
mg/kg = milligram per kilogram
PCB = polychlorinated biphenyl
PJKS = Former United States Air Force Plant PJKS
RAO = remedial action objective
SRO = soil remediation objective

RAOs are based on CDPHE's Tier 2 SROs for an industrial scenario (State of Colorado, 1997) established for PJKS

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TABLE 5
DESCRIPTION OF FINAL GROUNDWATER REMEDY COMPONENTS

Alternative Component	**Alternative 1 No Action**	**Alternative 2 In Situ Bioremediation with Environmental Covenants**
Treatment	None	ARD is being stimulated in the Fountain Formation and Precambrian aquifers at the seven source areas by injecting sodium lactate and/or EEO and a bioaugmentation culture in specific wells in these areas. Performance monitoring at the seven source areas shows that TCE in the groundwater is steadily decreasing as a result of bioremediation efforts.
Containment	None	Reducing the TCE concentrations in the source areas prevents further off-site migration of TCE contaminated groundwater.
Institutional Controls	None	The Restrictive Notice will restrict PJKS to industrial use. Restrictions will also be implemented to prohibit removal of the groundwater and will include controls to limit the exposure of site workers to the groundwater until bioremediation efforts have reduced TCE concentrations to levels that are protective for unrestricted use.
Operation and Maintenance	None	The major components of the alternative are the substrate material and then the means to inject the substrate to groundwater (i.e., via pumps and an appropriate energy source). The personnel, groundwater sampling equipment, and laboratory services necessary to continue operation and maintenance of the bioremediation system at PJKS are readily available and already in use at PJKS.
Monitoring Requirements	None	Routine compliance monitoring and preparation of O&M reports will be required to satisfy State requirements.

Notes:
ARD = Anaerobic Reductive Dechlorination
EEO = emulsified edible oil
O&M = operation and maintenance
PJKS = former USAF Plant PJKS
TCE = trichloroethene

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TABLE 6
GROUNDWATER CONTAMINANTS OF CONCERN (COCs)
CONCENTRATIONS AT THE SEVEN SOURCE AREAS

Source Area	Contaminant	Range of Values (micrograms /liter)	CBSG (micrograms/liter)
D-1	TCE	25 - 6,000	5
	cis-1,2-DCE	53 - 860	70
	trans-1,2-DCE	0.4 – 4.8	100
	1,1-DCE	Non-detect [ND] - 17	5
	VC	21 - 580	2
	NDMA	0.053 – 1.3	0.05**
SCA	TCE	40 – 1,600	5
	cis-1,2-DCE	4.8 – 640	70
	trans-1,2-DCE	ND – 26	100
	1,1-DCE	ND – 3.4	5
	VC	ND – 39	2
	NDMA	0.74 – 36	0.05**
EPL	TCE	970 – 11,000	5
	cis-1,2-DCE	6 – 1,900	70
	trans-1,2-DCE	ND – 0.74	100
	1,1-DCE	ND – 4	5
	VC	ND – 33	2
CSSA	TCE	0.19 – 170	5
	cis-1,2-DCE	ND – 19	70
	trans-1,2-DCE	ND – 0.058	100

TABLE 6
GROUNDWATER CONTAMINANTS OF CONCERN (COCs)
CONCENTRATIONS AT THE SEVEN SOURCE AREAS

Source Area	Contaminant	Range of Values (micrograms/liter)	CBSG (micrograms/liter)
	1,1-DCE	ND	5
	VC	ND – 14	2
	NDMA*	0.18 - 2.8	0.05**
OTL	TCE	6.2 – 15	5
	cis-1,2-DCE	6.8 – 23	70
	trans-1,2-DCE	ND	100
	1,1-DCE	ND – 0.1	5
	VC	ND – 5.1	2
T-8A	TCE	110 – 480	5
	cis-1,2-DCE	5.2 – 25	70
	trans-1,2-DCE	ND – 1.2	100
	1,1-DCE	ND – 0.12	5
	VC	ND	2
	NDMA*	0.86 – 1.1	0.05**
D-4	TCE	0.27 – 90	5
	cis-1,2-DCE	ND – 13	70
	trans-1,2-DCE	ND – 2.3	100
	1,1-DCE	ND – 0.32	5
	VC	ND – 32	2

TCE concentrations from the Performance Monitoring Report, 4th Quarter, Report #7
*NDMA concentrations from Annual Groundwater program 2009 fall sampling.
**NDMA value based on the Current Practical Quantitation Limit (PQL)

TABLE 7
RAOs FOR GROUNDWATER

Contaminant	CBSGs (µg/L)
TCE	5
cis-1,2-DCE	70
trans-1,2-DCE	100
VC	2
1,1-DCE	5
NDMA	0.05

Notes:
CBSG = Colorado Basic Standards for Groundwater
CDPHE = Colorado Department of Public Health and Environment
DCE = dichloroethene
µg/L = micrograms per liter
NDMA = nitrosodimethylamine
PJKS = Former United States Air Force Plant PJKS
PQL = practical quantitation limit
RAO = remedial action objective
TCE = trichloroethene
VC = vinyl chloride

RAOs are based on the CBSGs (CDPHE, 2009)

The Colorado State Standard for NDMA is 0.00069 µg/L. Colorado regulations state that if a standard is below the PQL of the approved analytical method, the PQL is the enforcement standard. The PQL for the currently approved method is 0.05 µg/L.

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TABLE 8
SUMMARY OF COMMON ELEMENTS AND DISTINGUISHING FEATURES OF EACH ALTERNATIVE

Element and Feature	**Alternative 1** **No Action**	**Alternative 2** **In Situ Bioremediation with Environmental Covenants**
Key ARARs and TBCs	The following chemical-specific ARARs are pertinent to this alternative: 5 CCR 1002-41 (CBSGs)	The following chemical-specific ARARs are pertinent to this alternative: • 5 CCR 1002-41 (CBSGs) The following action-specific ARARs and TBCs are pertinent to this alternative: • Colorado Environmental Covenant Act (CRS 25-15-317 through 327) • Memorandum of Agreement (Lockheed Martin, 2010) (TBC)
Long-term reliability	This alternative would provide no protection for human and ecological receptors.	Bioremediation is protective of the community and workers because it decreases the toxicity of source areas contributing to the groundwater contamination. There is no direct risk to site workers to implement in situ bioremediation. This alternative can be implemented using straightforward injection techniques. This technology has been successfully used at numerous sites across the country and at the PJKS site to remediate TCE. This technology is simple to operate and requires minimal maintenance.
Quantity of waste to be managed	No groundwater would be handled. All waste remains at the site.	No groundwater is removed as part of this remedy. Therefore, there will be no waste to be managed.
Estimated time for design and construction	None	Bioremediation is already being implemented at the seven source areas at PJKS, there is no additional time required to implement this remedy.
Estimated time to reach cleanup levels	None	The time to achieve significant source area reduction (as defined as asymptotic or achieving the CBSGs) is 3-5 years based on the D-1 ICM performance results.
Estimate costs	$66,168 ($24,000 total present worth)	$2,095,392 ($611,000 total present worth)

Notes:
ARAR = applicable or relevant and appropriate requirement
CBSG = Colorado Basic Standards for Groundwater
CCR = Code of Colorado Regulations
CRS = Colorado Revised Statute
ICM = Interim Corrective Measure
TBC = to be considered
TCE = trichloroethene

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TABLE 9
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

Criterion	No Action	In Situ Bioremediation with Environmental Covenants
Overall Protection of Human Health and the Environment	The source area in groundwater would remain as it currently exists with no active effort to minimize contaminant levels or migration pathways. No efforts would be made to reduce any potential risks to human health and the environment.	Is protective of human health and environment because it reduces the concentrations of COCs in groundwater source areas. Controls would be in place to restrict the installation of shallow groundwater wells for potable drinking water until the groundwater is fully remediated below CBSGs.
Compliance with ARARs	Is not compliant with the chemical-specific ARARs, specifically the CBSGs.	Complies with all potential ARARs (with the exception of those ARARs for which a TI waiver is sought).
Long-Term Effectiveness and Permanence	Does not provide long-term effectiveness or permanent remedy for the groundwater contamination. This alternative does not manage or reduce risks associated with the groundwater contamination.	Will achieve long-term effectiveness by treating groundwater contaminants through a non-reversible process of biodegradation with no waste products or residuals.
Reduction in Toxicity, Mobility, and Volume through Treatment	Does not provide an active treatment to reduce toxicity, mobility, or volume of contaminated groundwater at the PJKS site.	Uses in situ biodegradation to irreversibly reduce the toxicity and volume of contaminated groundwater by converting COCs to non-toxic by-products (i.e., ethene by-product from TCE degradation). However, this technology does not reduce the mobility of untreated groundwater.
Short-Term Effectiveness	Is not protective of the community and is not protective of workers who would encounter shallow groundwater during excavations. The environmental quality of groundwater will not be actively improved.	Is protective of the community and workers because it decreases the toxicity of source areas contributing to the groundwater contamination. There is no direct risk to site workers to implement in situ bioremediation (injecting a substrate into groundwater wells).
Implementability	No technical or administrative feasibility concerns are associated with implementing this Alternative because no actions are being taken.	The required personnel and operation of this Alternative is technically feasible for sites that fit the preferred remedy profile. This alternative can be implemented using straightforward injection techniques. This technology has been successfully used at numerous sites across the country and at the PJKS site to remediate TCE. This technology is simple to operate and requires minimal maintenance and is a proven technology at all seven PJKS groundwater source areas.

TABLE 9
COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

Criterion	**No Action**	**In Situ Bioremediation with Environmental Covenants**
Projected State Acceptance		
Projected Community Acceptance		
Costs	$24,000 Total Present Worth	$611,000 Total Present Worth

Notes:
ARAR = applicable or relevant and appropriate requirement
CBSG = Colorado Basic Standards for Groundwater
COC = contaminant of concern
PJKS = Former United States Air Force Plant PJKS
TCE = trichloroethene
TI = technical impracticability

TABLE 10
NON-RESIDENTIAL LAND USE RESTRICTIONS

SWMU	COC Concentration	Limited Cover Required	Area of Cover	Restrictions
13, 15, 16, 17, 19, 20, 21, 22, 24, 25, 33, and 34	SROs < COCs < RAOs	No	NA	Property will only be used for industrial purposes. Workers performing excavation or soil disturbing activities will have to be appropriately trained and wear the proper personal protective equipment. Groundwater in the area is restricted from use as drinking water.
8	RAOs < PCBs	Yes	T-8A Surface Impoundment Basin	Property will only be used for industrial purposes. Workers performing excavation or soil disturbing activities will have to be appropriately trained and wear the proper personal protective equipment. Groundwater in the area is restricted from use as drinking water. The integrity and ongoing effectiveness of the limited cover be maintained and checked annually.
12	RAOs < PCBs	Yes	Valve Area 1; near Building T-5A	
29	RAOs < PCBs	Yes	SCA Areas 4 and 5; near Buildings T-27 and T-28A	
31	RAOs < PCBs	Yes	Area near Building T-23	
CSA-3	RAOs < PCBs	Yes	>25 feet of backfill soil cover near former D-1 Landfill footprint	

Notes:
COC = contaminant of concern
CSA-3 = Contaminated Soil Area 3
CDPHE = Colorado Department of Public Health and Environment
NA = not applicable
PCB = polychlorinated biphenyl
PJKS = Former United States Air Force Plant PJKS
RAO = remedial action objective
SCA = Systems and Components Area
SRO = Soil Remediation Objective
SWMU = solid waste management unit

RAOs are based on CDPHE's Tier 2 SROs for an industrial scenario (State of Colorado, 1997) established for PJKS

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TABLE 11
SELECTED REMEDY - IN SITU BIOREMEDIATION AND RESTRICTIVE NOTICE
COST SUMMARY

Task	Unit	Unit Cost	# of Units	Total Cost
Capital Costs				
Round of Injection				
Equipment	day	$388.81	60	$23,328.60
Labor	each	$279,775.94	1	$279,775.94
EVO Bioremediation Substrate	pounds	$3.16	13000	$41,080.00
				$344,184.54
Well Abandonment				
Well abandonment - Lariate Gulch (year 30)	each	$416,579.00	1	$416,579.00
Well abandonment - Horizontal (year 30)	each	$28,167.00	1	$28,167.00
Well abandonment - Remaining wells (year 30	each	$278,399.00	1	$278,399.00
				$723,145.00
Total Capital Costs				**$1,067,329.54**
Periodic Costs (30 years)				
Groundwater Monitoring (2010)				
Groundwater Sampling	year	$55,374.00	1	$55,374.00
Data Management	year	$58,589.00	1	$58,589.00
General Monitoring	year	$4,388.00	1	$4,388.00
				$118,351.00
Groundwater Monitoring (2011-2015)				
Groundwater Sampling	year	$35,556.00	5	$177,780.00
Data Management	year	$11,095.00	5	$55,475.00
General Monitoring	year	$2,470.00	5	$12,350.00
				$245,605.00
Groundwater Monitoring (2011-2035)				
Groundwater Sampling	year	$19,818.00	25	$495,450.00
Data Management	year	$7,597.00	25	$189,925.00
General Monitoring	year	$1,918.00	25	$47,950.00
				$733,325.00
Administrative Land Use Controls				
Monitoring and Enforcement	year	$2,710.00	30	**$81,300.00**
Five Year Review (Every 5 years starting year 5)				
Document Review	each	$6,215.00	6	$37,290.00
Site Inspection	each	$2,462.00	6	$14,772.00
Report	each	$8,566.00	6	$51,396.00
				$103,458.00
Total Periodic Costs				**$1,282,039.00**
Typical Annual Costs				**$32,043.00**
Total Present Worth				**$611,000.00**

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TABLE 12
ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Status	Description
CHEMICAL SPECIFIC ARARS			
Federal			
Safe DrinkingWater Act			
National Primary Drinking Water Standards	40 CFR 141	Relevant and Appropriate	Establishes maximum contaminant levels (MCLs) for organic and inorganic constituents in public water systems for the protection of human health The MCLs for TCE and its degradation products are the same for the state standards.. There is no federal MCL for NDMA.
State of Colorado			
Colorado Department of Public Health And Environment			
Colorado Basic Standard for Groundwater (CBSG)	5 CCR 1002-41	Applicable	The preferred alternative uses the statewide health-based Standards, including NDMA, for waters of the state for RAOs.
Colorado Rules and Regulations Pertaining to Hazardous Waste	6 CCR 1007, Part 261	Relevant and Appropriate	Establishes listing requirements of hazardous wastes.
Colorado Primary Drinking Water Regulations	5 CCR 1003-1	Relevant and Appropriate	Establishes drinking water standards that apply to specific contaminants and have been determined to have an adverse effect on human health.
To Be Considered			
Requirements for the Analysis of NDMA in PJKS Groundwater	CDPHE, 2008	TBC	Approves new analytical method with lower method detection limits and practical quantitation limits for the analysis of NDMA in PJKS groundwater. The PQL specified for this method becomes the defacto CBSG for NDMA in PJKS groundwater because there are no available analytical methods capable of detecting NDMA in groundwater down to the actual CBSG.
LOCATION SPECIFIC ARARS			
Federal			
National Archaeological and Historical Preservation Act	16 USC 469; 36 CFR Part 65	Relevant and Appropriate	This act requires that any artifacts present at the site are recovered and preserved. Compliance with the act is achieved if a mitigation plan is prepared and implemented, should cultural resources be threatened.
National Historic Preservation Act	16 USC 470	Relevant and Appropriate	Authorizes the Secretary of the Interior to expand and maintain a National Register of Historic Places.
LOCATION SPECIFIC ARARS cont.			
Federal cont.			
Endangered Species Act	16 USC 1531	Relevant and	Protection of endangered species and their habitats. No

TABLE 12
ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Status	Description
		Appropriate	threatened and endangered species are present at PJKS; if a threatened or endangered species were to be encountered, then requirements of the act could be applicable.
State of Colorado			
Colorado Non-Game, Endangered, or Threatened Species Conservation Act	CRS 33-2-101	Relevant and Appropriate	Regulates construction that jeopardizes critical habitat or designated species. May be applicable if state-designated species were to be encountered.
Historical, Prehistorical, and Archaeological Resources Act	8 CCR 1504-7	Relevant and Appropriate	Coordinates, encourages, and preserves the full understanding of Colorado's archaeological and paleontological resources for the benefit of Colorado's citizens.
Colorado Register of Historic Places Act	CRS 24-80.1-101 to 108	Relevant and Appropriate	Establishes that sites and structures possessing historical significance are cultural resources of the state and should be preserved.
ACTION SPECIFIC ARARS			
Federal			
Safe Drinking Water Act			
Underground Injection Control	40 CFR Parts 9, 144, 145, 146	Applicable	The preferred alternative will require injection of substrates and microbes (as fluids) for aquifer remediation into the groundwater via injection wells.
State of Colorado			
Colorado Department of Public Health and Environment			
Colorado Water Well Construction Rule 2	2 CCR 402-2 Rule 16	Applicable	The preferred alternative will require well abandonment as part of the corrective action. This regulation sets standards for monitoring well construction and abandonment in the State of Colorado
Colorado Environmental Covenant Act	CRS 25-15-317 through 327	Applicable	The preferred alternative will require an environmental covenant for the remedy that is not designed to achieve unrestricted use upon completion of remedy.

TABLE 12
ARARs

Notes:

CCR = Colorado Code of Regulations
CDPHE = Colorado Department of Public Health and Environment
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
CRS = Colorado Revised Statute
NDMA = n-nitrosodimethylamine
PJKS = Former United States Air Force Plant PJKS
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act
SWMU = solid waste management unit
TBC = To Be Considered
USC = United States Code

CDPHE. 2008. Letter regarding Requirements for the Analysis of N-Nitrosodimethylamine (NDMA) in Former Air Force Plant PJKS Groundwater, Compliance Order on Consent 98-10-08-01, U.S. Air Force Plant PJKS: CO7570090038. From David Walker, State Project Manager. To Corey Lam, Environmental Restoration Manager, U.S. Air Force Aeronautical Systems Center. May 19.

Colorado Department of Public Health and Environment. (CDPHE). 2002. *Corrective Action Guidance Document.* Hazardous Materials and Waste Management Division, May.

CDPHE. 2010. Letter regarding Requirements for Submittal of the Feasibility Study Work Plan and the Feasibility Study Report for Operable Unit Nos. 4 and 5/Solid Waste Management Units Nos. 1, 2 and 3, Compliance Order on Consent 98-10-08-01. From David Walker, State Project Manager and David Rathke, EPA Project Manager. To Corey Lam, Environmental Restoration Manager, U.S. Air Force Aeronautical Systems Center. January 25.

Lockheed Martin Corporation, Space Systems Company. 2010. Memorandum of Agreement between Lockheed Martin Corporation and the Department of the Air Force stating that the Air Force will perform future corrective actions to address contaminants on and from the Former Air Force Plant PJKS. Signed by Lockheed Martin Corporation and United States Air Force. March 15.

State of Colorado, 1998, *Compliance Order on Consent*

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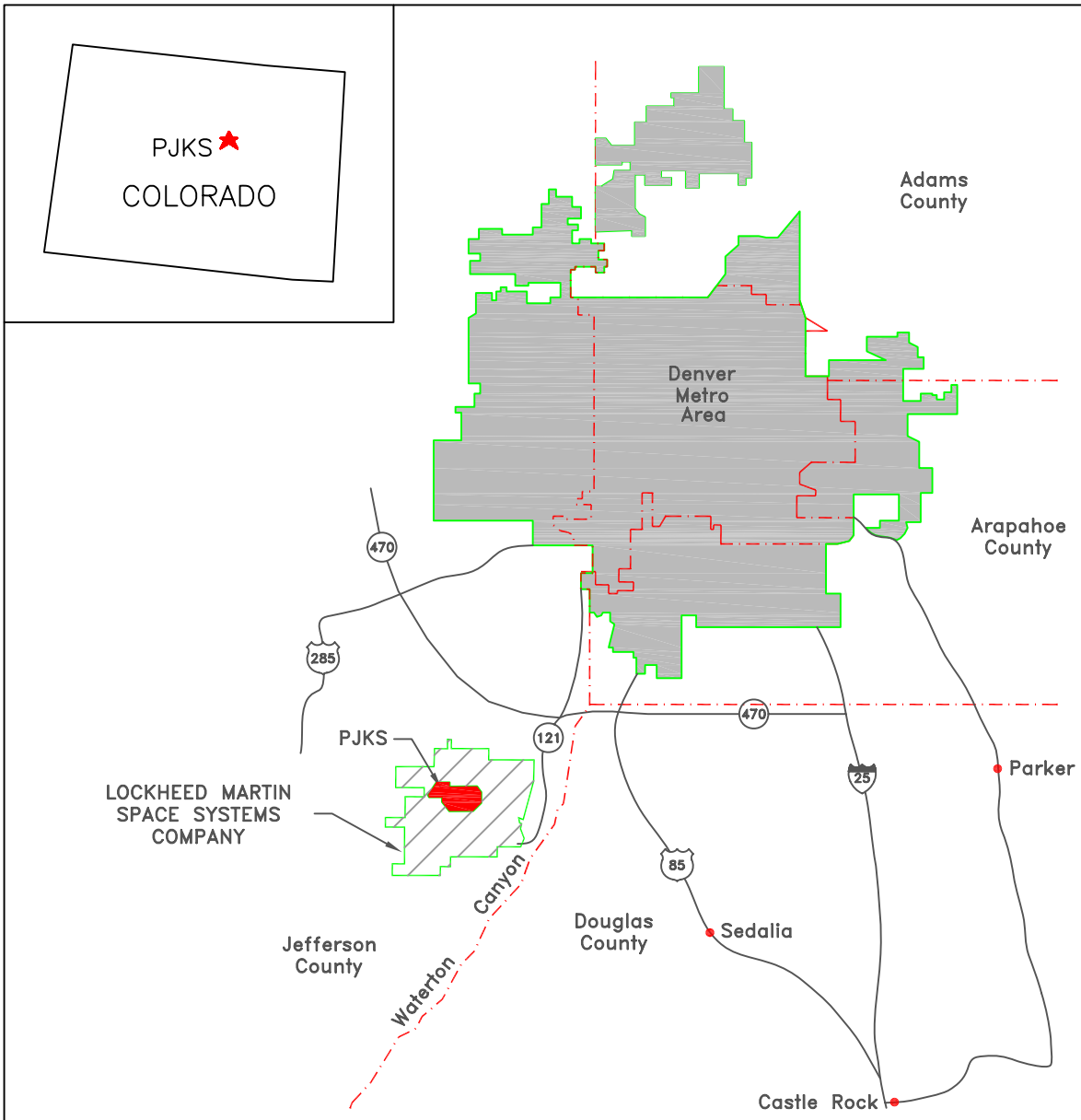
Figures



LEGEND

Former Air Force Plant PJKS

Lockheed Martin Space Systems Company

Denver Metro Area

County Line

N

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FORMER AIR FORCE PLANT PJKS

FIGURE NUMBER 1

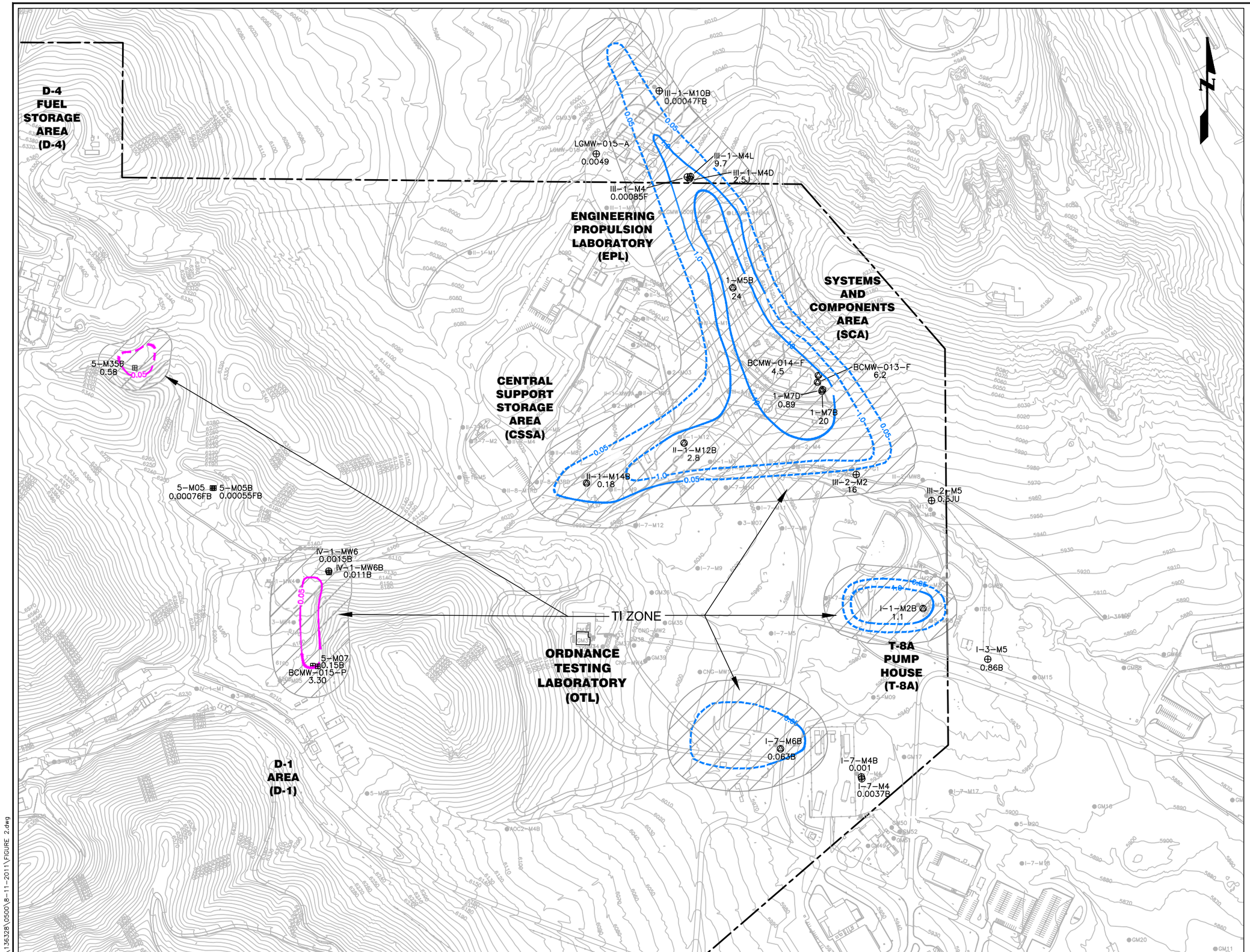
PJKS LOCATION MAP

REVISION	DESCRIPTION	CHKD	APPR	DATE
0	ISSUE TO PJKS TEAM	LGA	TC	

	BY	DATE		BY	DATE		BY	DATE		BY	DATE
DSGN	LWA	08/29/06	DRAWN	MEC	08/29/06	CHKD	LWA	08/30/06	APPR	PSM	08/30/06

PROJECT NO.	REV.	FILE NAME
136328.0500	0	FIGURE 1

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\FIGURE 1 mgj.dwg



LEGEND

2-M10D	WELLS NOT SAMPLED
18.00	NDMA CONCENTRATION IN µg/L)
ND	NOT DETECTED (LABORATORY DETECTION LIMIT = 0.5 µg/L)
	PJKS BOUNDARY
0.05	FOUNTAIN CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
0.05	PRECAMBRAIN CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
	TI ZONE, LATERAL EXTENT

NOTE:

TI ZONE IS DEFINED BY THE BEDROCK GROUNDWATER PLUMES FOOTPRINTS FOR NDMA (INCLUDES FOUNTAIN FORMATION AND PRECAMBRIAN AQUIFER).

ISO-CONTOURS PRESENTED FROM FALL 2009 NDMA RESULTS.

0 200 400 800

SCALE: 1" = 400'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	TC	PSM	06/15/10

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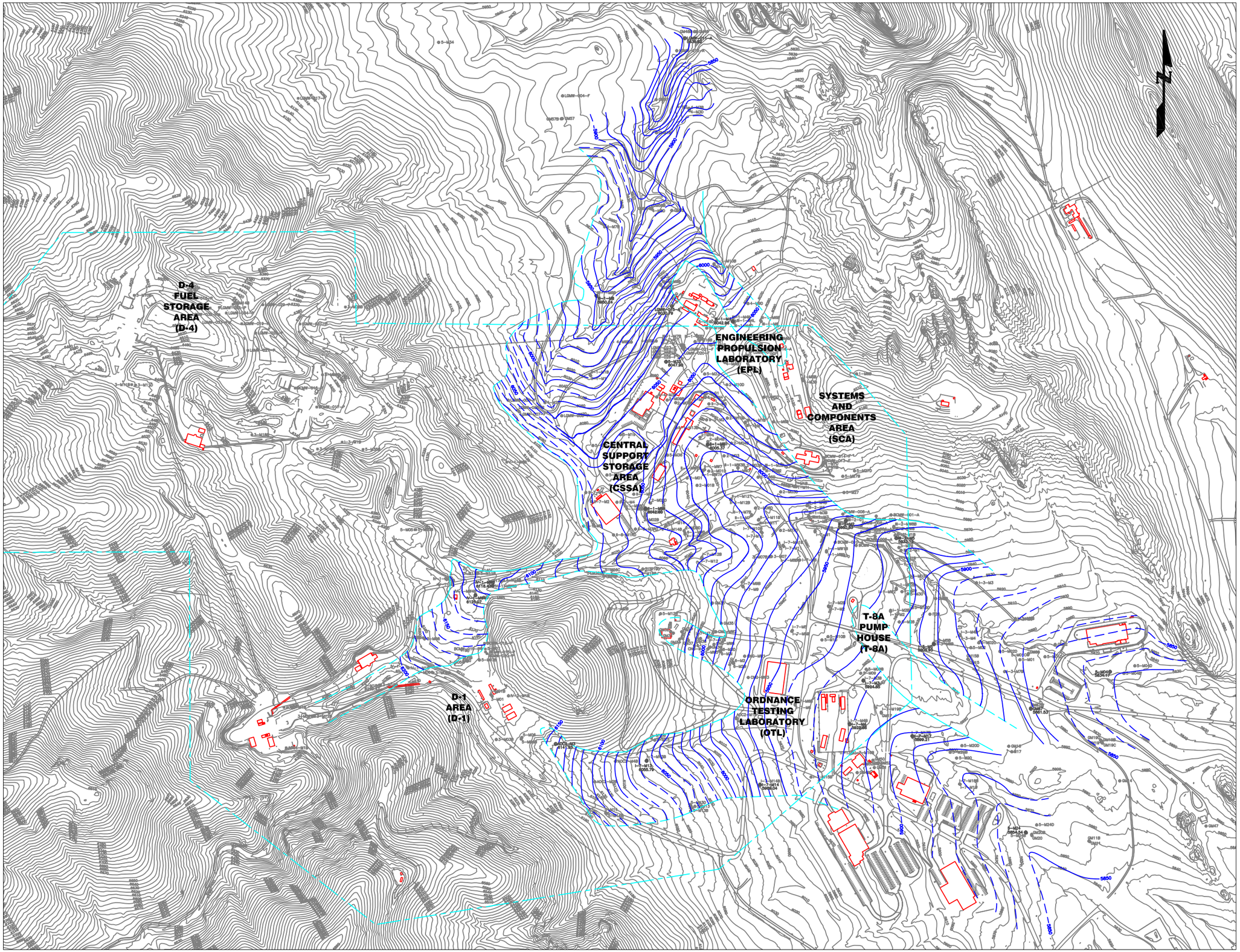
FIGURE NUMBER 2

TECHNICAL IMPRACTICABILITY ZONE LOCATIONS

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	TR	03/09/05	CHECKED	TC	03/17/05	136328.0400	0	FIGURE 2
DRAWN	MEC	03/09/05	APPROVED	PSM	03/17/05			

C:\136328\0500\8-11-2011\FIGURE 2.dwg



LEGEND

2–M10D	WELLS NOT MEASURED
5–M32	WELLS MEASURED IN FALL 2009
6077.96	GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
	PJKS BOUNDARY
	EXTENT OF SATURATED ALLUVIUM (DASHED WHERE INFERRED)
6100	POTENTIOMETRIC SURFACE CONTOUR (DASHED WHERE INFERRED)
	CONTOUR INTERVAL = 10 FT.

0 300 600 1200

SCALE: 1" = 600'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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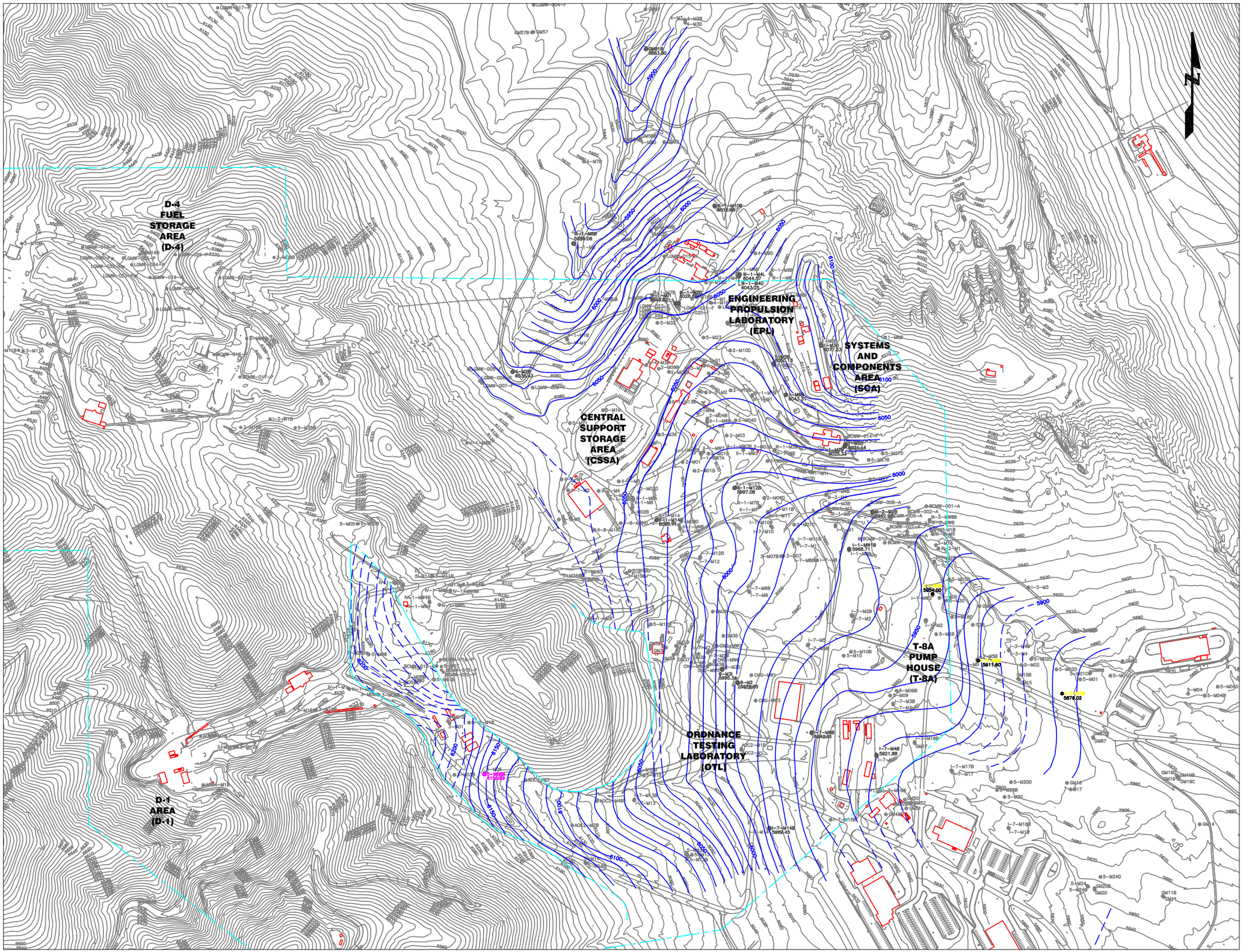
FIGURE NUMBER 3

ALLUVIAL AQUIFER POTENTIOMETRIC SURFACE MAP FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 3
DRAWN	JVR	12/31/09	APPROVED	TC	03/12/10			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGA\FIGURE 3 mgj.dwg



LEGEND

2–M10D	WELLS NOT MEASURED
5–M32	WELLS MEASURED IN FALL 2009
6077.96	GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
	PJKS BOUNDARY
	PRECAMBRIAN/FOUNTAIN FORMATION CONTACT (DASHED WHERE INFERRED)
6100	POTENTIOMETRIC SURFACE CONTOUR (DASHED WHERE INFERRED)
	CONTOUR INTERVAL = 10 FT.

0 250 500 1000

SCALE: 1" = 500'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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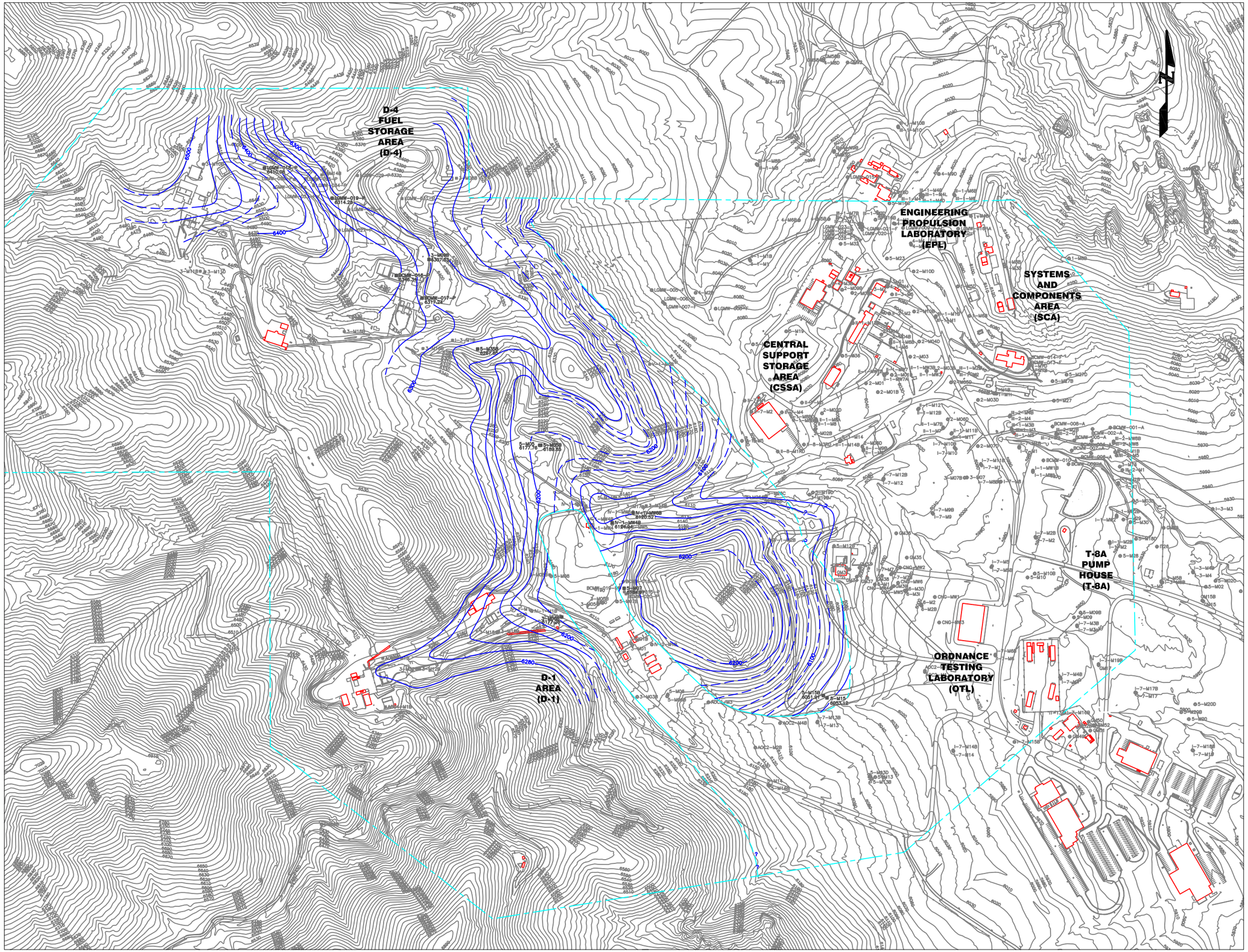
FIGURE NUMBER 4

FOUNTAIN AQUIFER POTENTIOMETRIC SURFACE MAP FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 4
DRAWN	JVR	12/31/09	APPROVED	TC	03/12/10			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Show files 9-18-12\MGJ\FIGURE 4 mgj.dwg



LEGEND

2–M10D	WELLS NOT MEASURED
5–M32	WELLS MEASURED IN FALL 2009
6077.96	GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL
	PJKS BOUNDARY
	PRECAMBRIAN/FOUNTAIN FORMATION CONTACT (DASHED WHERE INFERRED)
6100	POTENTIOMETRIC SURFACE CONTOUR (DASHED WHERE INFERRED)
	CONTOUR INTERVAL = 20 FT.

0 250 500 1000

SCALE: 1" = 500'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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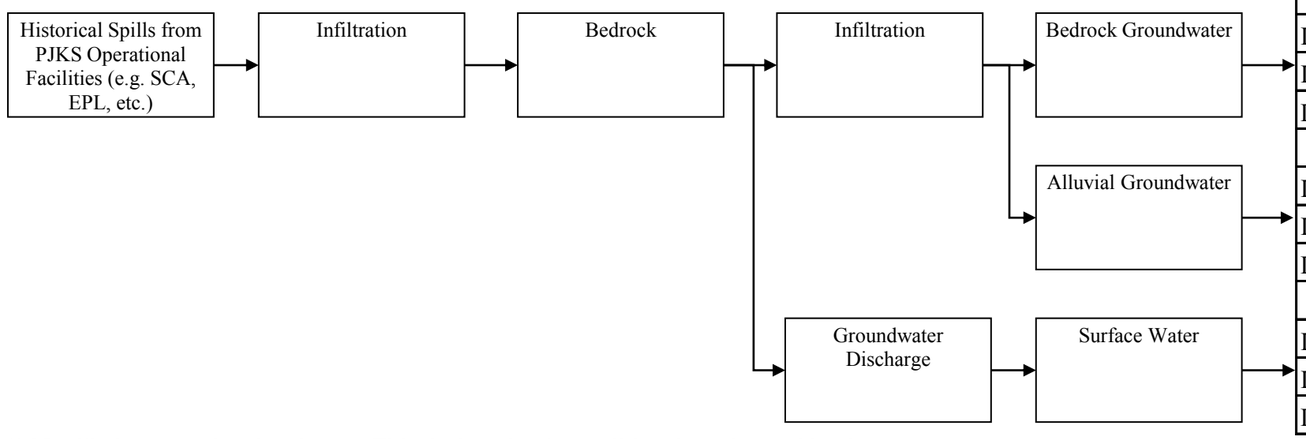
FIGURE NUMBER 5

PRECAMBRIAN AQUIFER POTENTIOMETRIC SURFACE MAP FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 5
DRAWN	JVR	12/31/09	APPROVED	TC	03/12/10			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGJ\FIGURE 5 mgj.dwg

Figure 6
Generalized Conceptual Site Model
Former Air Force Plant PJKS Groundwater



POTENTIAL RECEPTORS

	HUMAN			ECOLOGICAL	
Exposure Route	Current Site Worker	Future Site Worker	Future Offsite Receptor	Terrestrial	Aquatic
Ingestion		✓(1)	✓		
Inhalation (vapor)(2)		✓	✓		
Dermal Contact		✓	✓		
Ingestion		✓	✓		
Inhalation (vapor)(2)		✓	✓		
Dermal Contact		✓	✓		
Ingestion		✓	✓		
Inhalation (vapor)					
Dermal Contact		✓	✓		

1) Not likely a completed pathway. This designation is conditional on changed land use or future use of groundwater.

2) Based on EPA's Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway From Groundwater and Soils (EVI) (OSWER, November 29, 2002) definition of "inhabited buildings", which are structures with enclosed air space that are designed for human occupancy and are "near" (100 feet laterally or vertically) known groundwater contaminants listed in Table 1 of the EVI. Trichloroethene, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene, 1,1-Dichloroethene, and vinyl chloride are listed on Table 1 of the EVI.

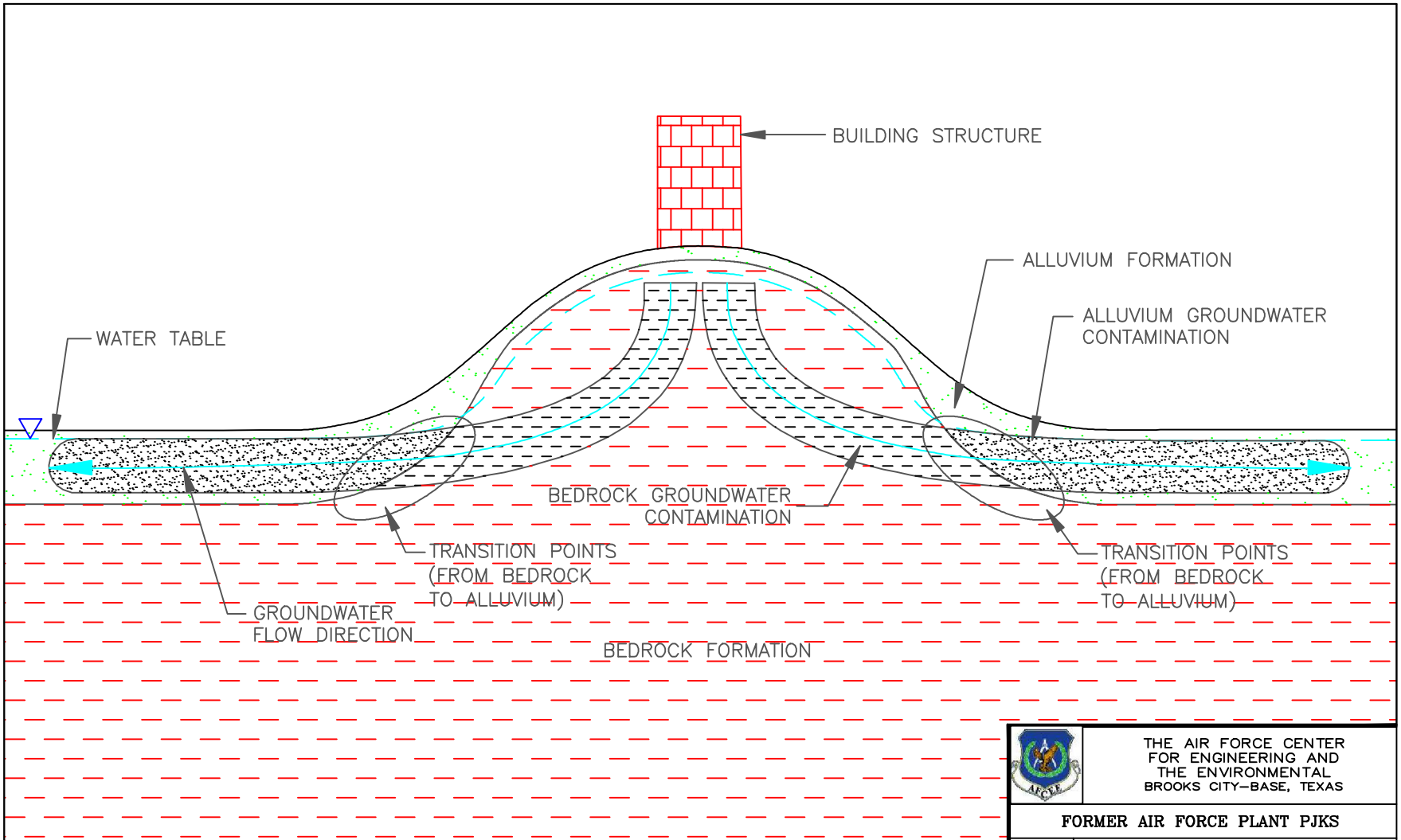


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FIGURE NUMBER 7

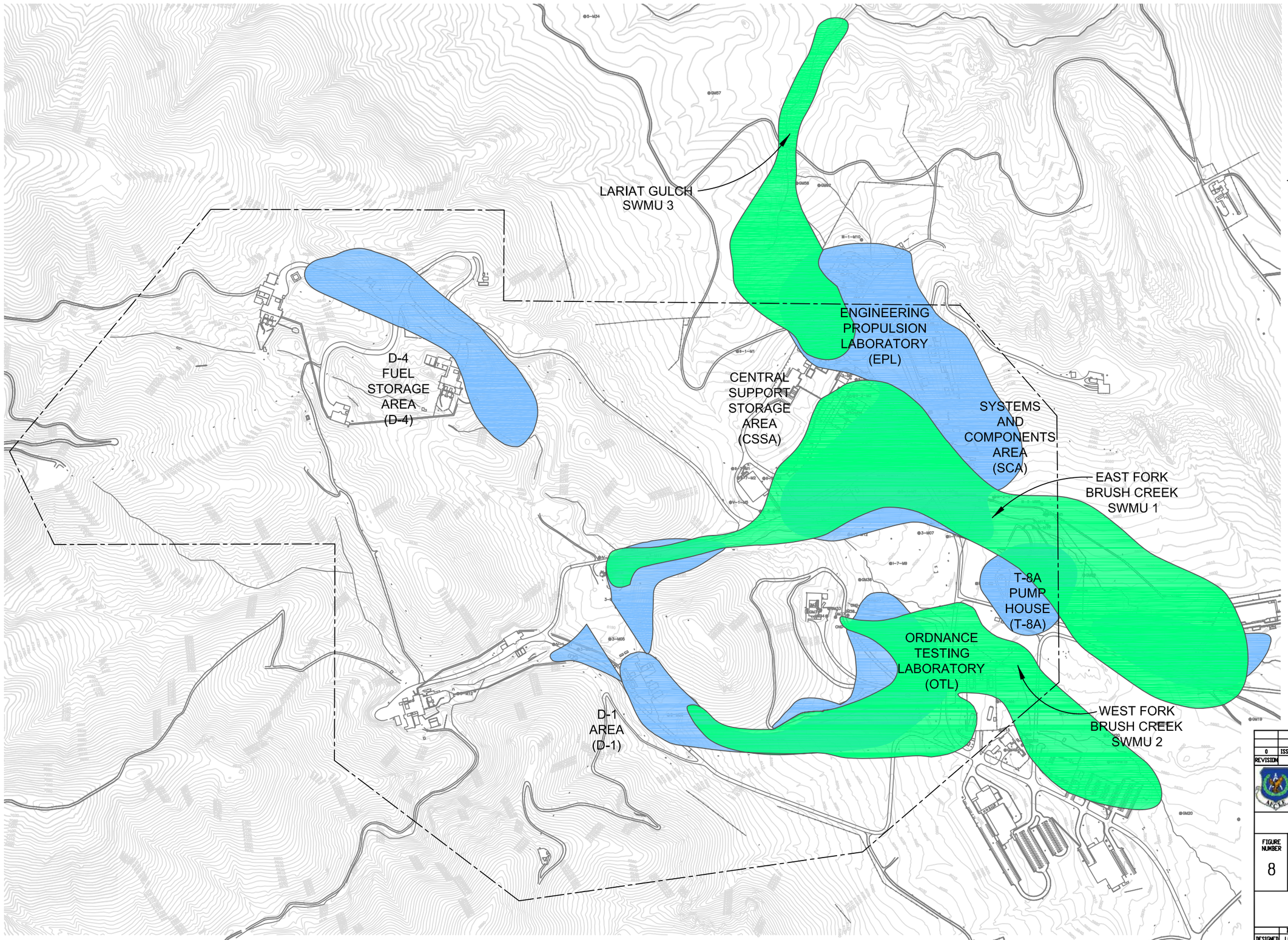
CONCEPTUAL SITE MODEL

REVISION	DESCRIPTION	CHKD	APPR	DATE
0	ISSUED TO AGENCIES	LGA	TC	

	BY	DATE		BY	DATE		BY	DATE		BY	DATE
DSGN	TC	12/31/09	DRAWN	JWR	12/31/09	CHKD	TC	03/12/10	APPR	TC	03/12/10

PROJECT NO.	REV.	FILE NAME
136328.0500	0	FIGURE 7

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Show files 9-18-12\MGJ\FIGURE 4 mgj.dwg



LEGEND

— — —	PJKS BOUNDARY
	BEDROCK GROUNDWATER TCE CONTAMINATION
	ALLUVIAL GROUNDWATER TCE CONTAMINATION
SWMU	SOLID WASTE MANAGEMENT UNIT

0 600 1200

SCALE: 1″ = 600′

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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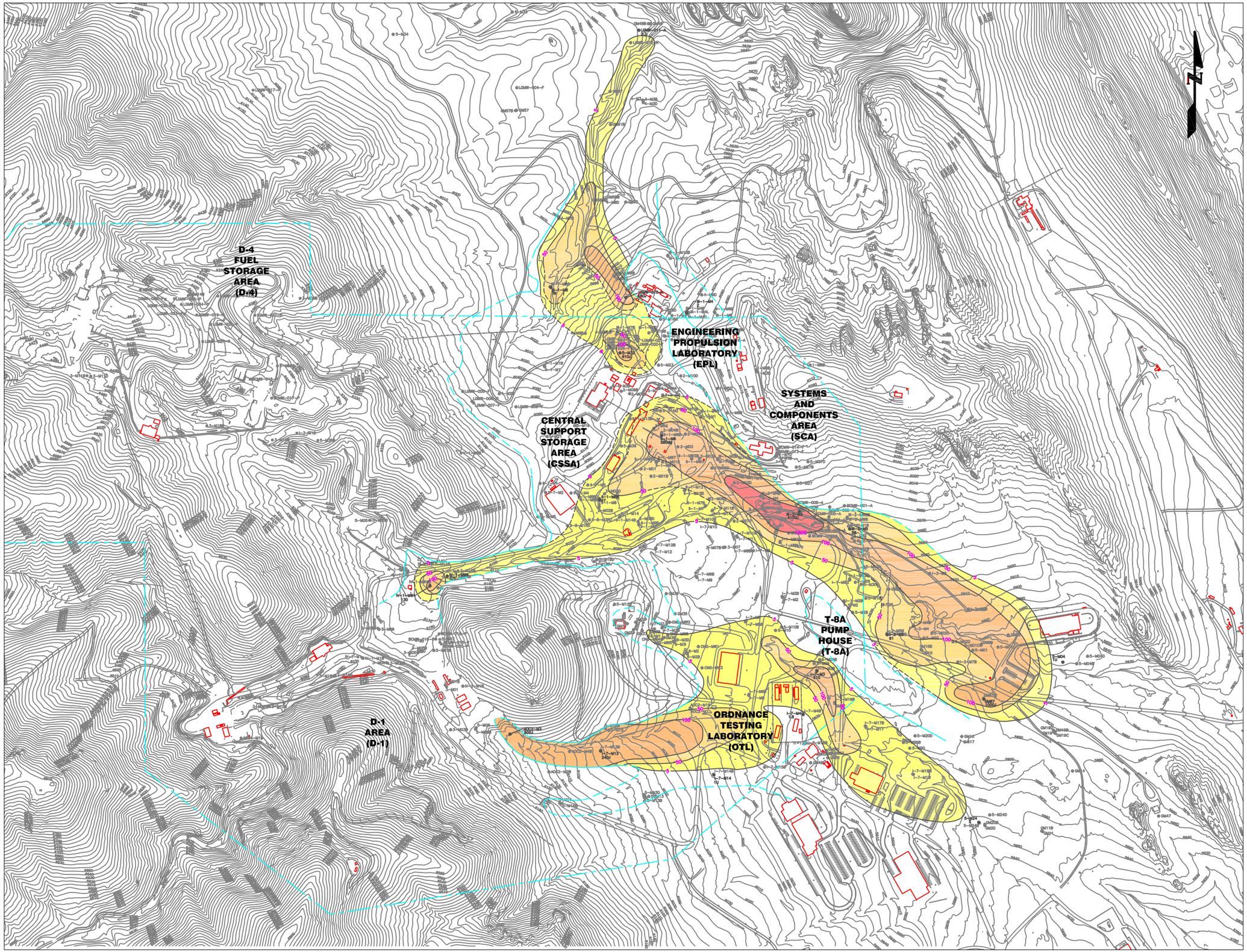
FIGURE NUMBER 8

GROUNDWATER SWMUs
AND SOURCE AREAS

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	LGA	07/06/10	CHECKED				0	
DRAWN		07/06/10	APPROVED					



NOTE

1. PLUMES BASED ON CURRENT AND HISTORICAL DATA

LEGEND

- 2-M10D — WELLS NOT SAMPLED
- 5-M32 — WELLS SAMPLED IN FALL 2009
- 720J — TCE CONCENTRATION IN µg/L
- PJKS BOUNDARY
- EXTENT OF SATURATED ALLUVIUM (DASHED WHERE INFERRED)
- 5 — CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
- 5–50 µg/L
- 50–100 µg/L
- 100–1,000 µg/L
- >1,000 µg/L

DATA QUALIFIERS

F AN ESTIMATED VALUE – THE ANALYTE WAS POSITIVELY IDENTIFIED BUT THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.

J AN ESTIMATED VALUE – AS WITH "F" QUALIFIER, THE ANALYTE WAS POSITIVELY IDENTIFIED BUT THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.

JM ESTIMATED VALUE BECAUSE MATRIX SPIKE RECOVERY OUTSIDE QUALITY CONTROL LIMITS.

#U RESULT IS NON-DETECT WITH #=REPORTING LIMIT. DIFFERENCES IN THE REPORTING LIMIT VALUE ARE DUE TO THE DILUTION FACTOR.

0 300 600 1200

SCALE: 1" = 600'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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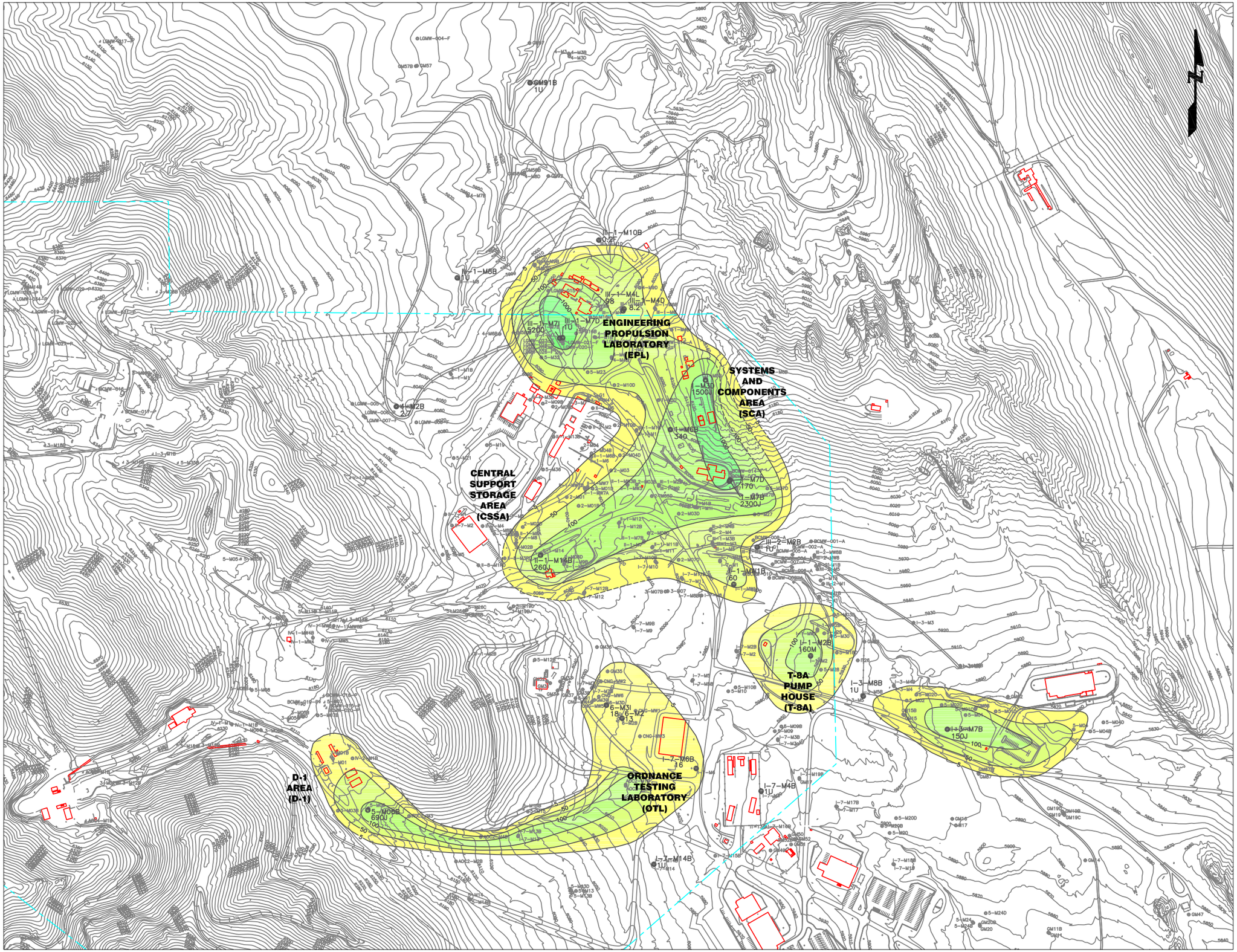
FIGURE NUMBER 9

TCE PLUME ALLUVIAL AQUIFER FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 9
DRAWN	JVR	12/31/09	APPROVED	TC	03/12/10			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGJ\FIGURE 9 mgj.dwg



K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGJ\FIGURE 10 mgj.dwg

NOTE

1. PLUMES BASED ON CURRENT AND HISTORICAL DATA

LEGEND

2-M10D	WELLS NOT SAMPLED
III-1-M4L	WELLS SAMPLED IN FALL 2009
91	TCE CONCENTRATION IN µg/L
	PJKS BOUNDARY
5	CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
	5–50 µg/L
	50–100 µg/L
	100–1,000 µg/L
	>1,000 µg/L

DATA QUALIFIERS

F AN ESTIMATED VALUE – THE ANALYTE WAS POSITIVELY IDENTIFIED BUT THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.

J AN ESTIMATED VALUE – AS WITH "F" QUALIFIER, THE ANALYTE WAS POSITIVELY IDENTIFIED BUT THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.

JM ESTIMATED VALUE BECAUSE MATRIX SPIKE RECOVERY OUTSIDE QUALITY CONTROL LIMITS.

#U RESULT IS NON-DETECT WITH #=REPORTING LIMIT. DIFFERENCES IN THE REPORTING LIMIT VALUE ARE DUE TO THE DILUTION FACTOR.

0 250 500 1000

SCALE: 1" = 500'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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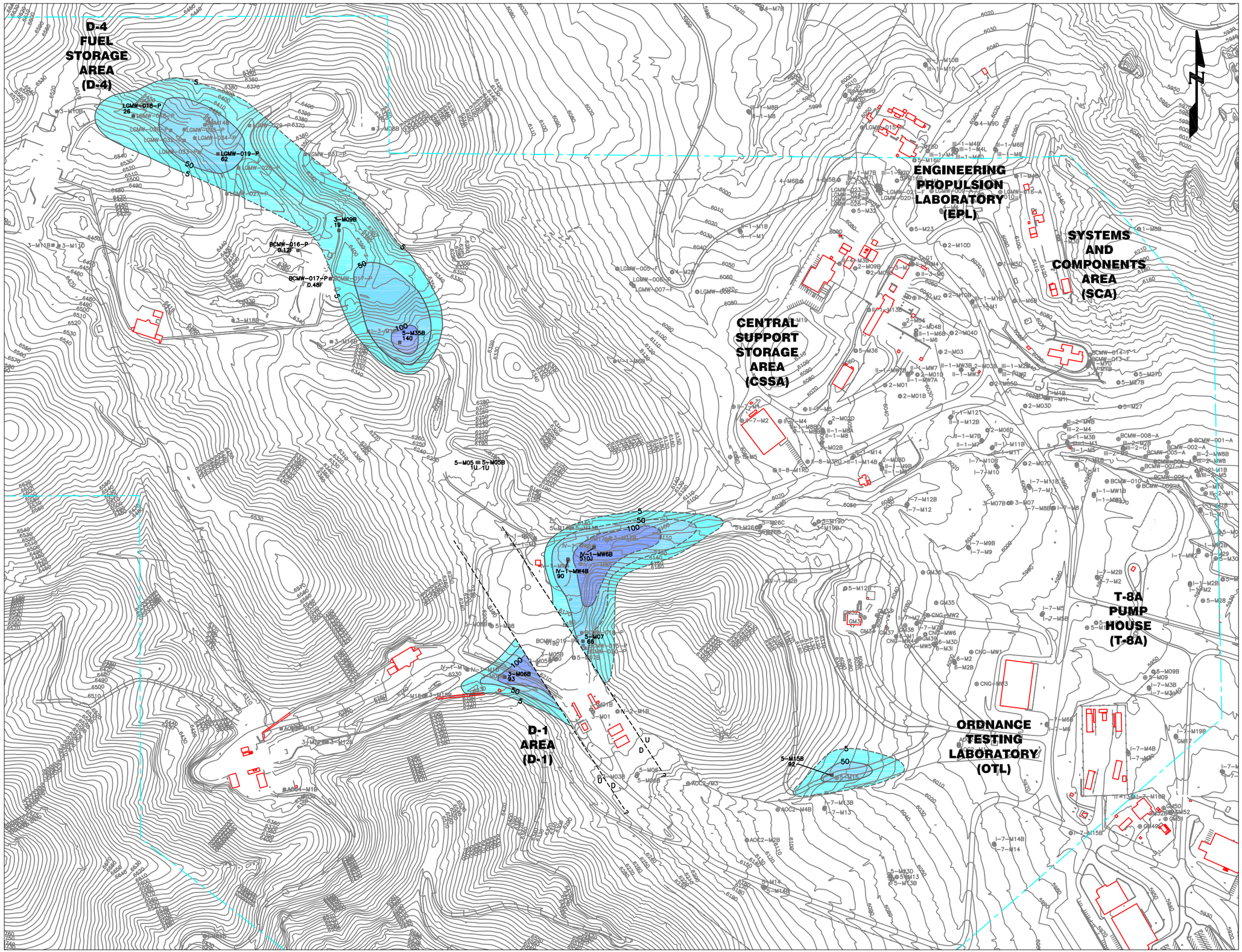
FIGURE NUMBER 10

TCE PLUME FOUNTAIN AQUIFER FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 10
DRAWN	JVR	12/31/09	APPROVED	TC	03/12/10			



NOTE

1. PLUMES BASED ON CURRENT AND HISTORICAL DATA

LEGEND

2-M10D	WELLS NOT SAMPLED
5-M32	WELLS SAMPLED IN FALL 2009
720J	TCE CONCENTRATION IN µg/L
	PJKS BOUNDARY
5	CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
U D U D	FAULTS
	5–50 µg/L
	50–100 µg/L
	100–1,000 µg/L

DATA QUALIFIERS

F AN ESTIMATED VALUE – THE ANALYTE WAS POSITIVELY IDENTIFIED BUT THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.

J AN ESTIMATED VALUE – AS WITH "F" QUALIFIER, THE ANALYTE WAS POSITIVELY IDENTIFIED BUT THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.

#U RESULT IS NON-DETECT WITH #=REPORTING LIMIT. DIFFERENCES IN THE REPORTING LIMIT VALUE ARE DUE TO THE DILUTION FACTOR.

0 200 400 800

SCALE: 1" = 400'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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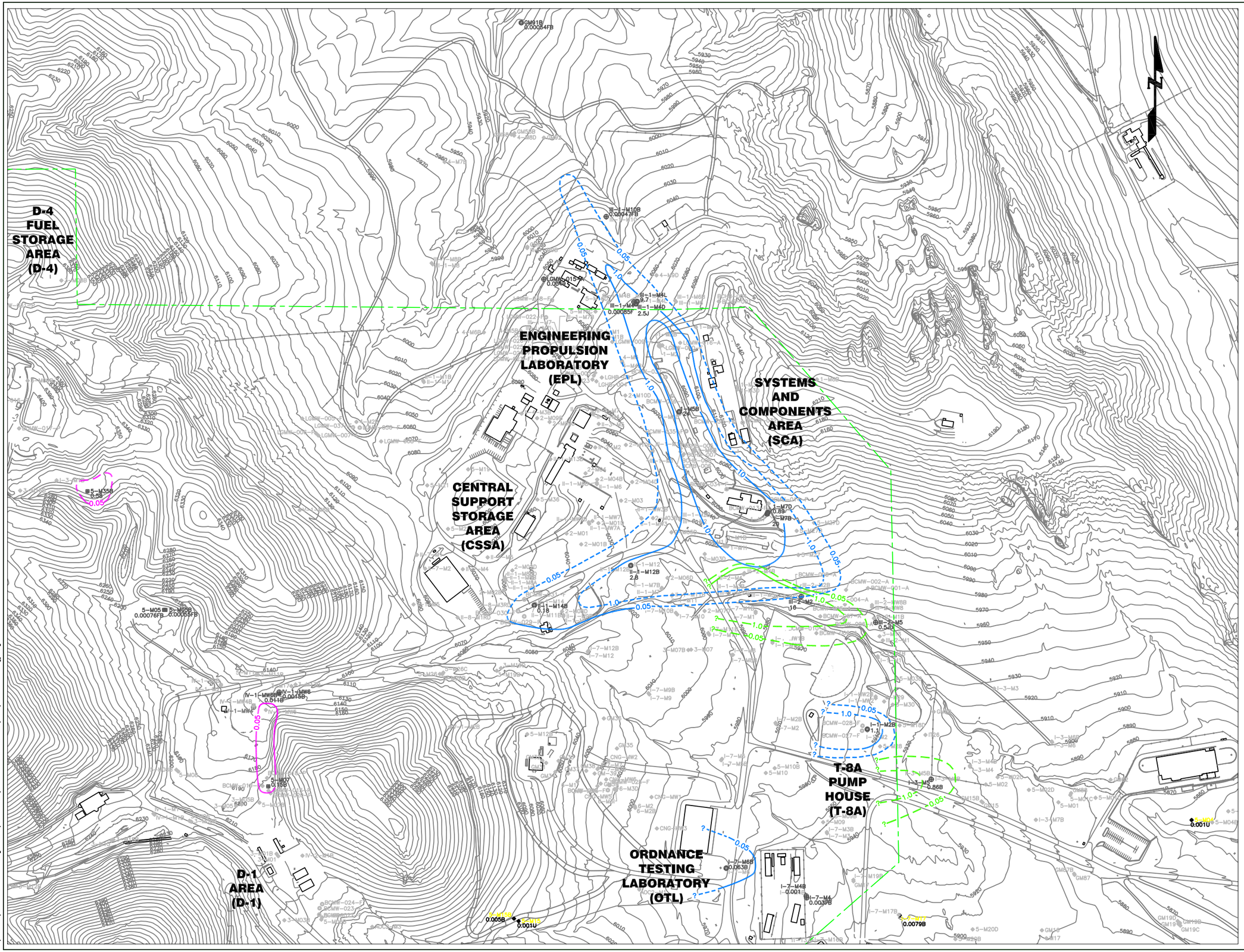
FIGURE NUMBER 11

TCE PLUME PRECAMBRIAN AQUIFER FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 11
DRAWN	JVR	12/31/09	APPROVED	TC	03/12/10			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGA\FIGURE 11 mgj.dwg



LEGEND

5–M11B	WELLS NOT SAMPLED
5–M35B	WELLS SAMPLED IN SPRING 2009
0.001U	NDMA CONCENTRATION IN µg/L
ND	NOT DETECTED (LABORATORY DETECTION LIMIT = 0.5 µg/L)
	PJKS BOUNDARY
0.05	ALLUVIAL CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
0.05	FOUNTAIN CONCENTRATION CONTOUR (DASHED WHERE INFERRED)
0.05	PRECAMBRAIN CONCENTRATION CONTOUR (DASHED WHERE INFERRED)

DATA QUALIFIERS

B	THE ANALYTE WAS FOUND IN AN ASSOCIATED BLANK.
F	THE ANALYTE WAS POSITIVELY IDENTIFIED, HOWEVER THE ASSOCIATED NUMERICAL VALUE IS BELOW THE REPORTING LIMIT.
J	THE ANALYTE WAS POSITIVELY IDENTIFIED, THE QUANTITATION IS AN ESTIMATE.
U	THE ANALYTE WAS ANALYZED FOR, BUT NOT DETECTED. NUMERICAL VALUE PRECEDING THE "U" IS THE REPORTING LIMIT.

0 200 400 800

SCALE: 1" = 400'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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BROOKS CITY-BASE, TEXAS

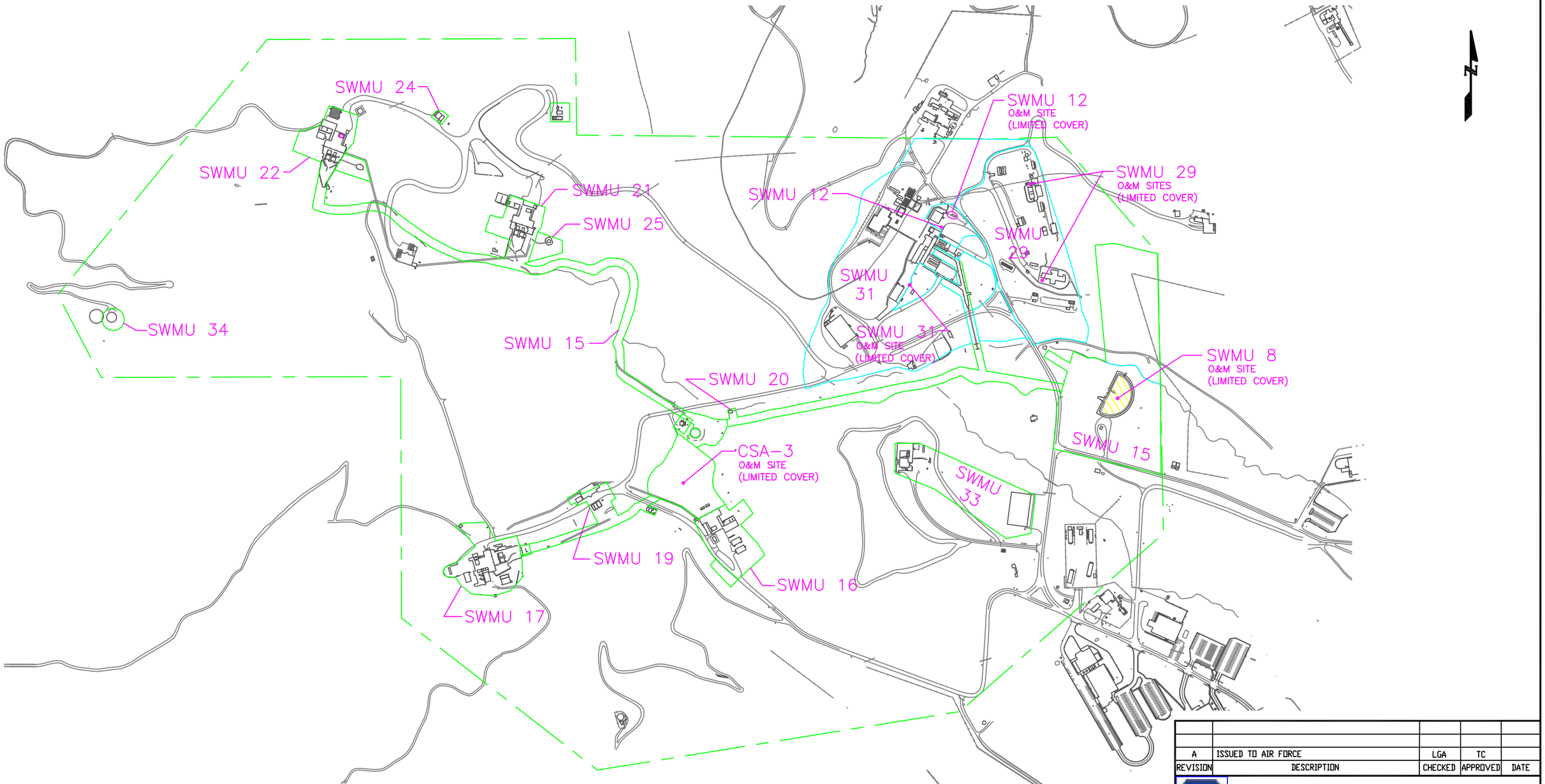
FORMER AIR FORCE PLANT PJKS

FIGURE NUMBER 12

NDMA PLUME COMBINED AQUIFERS FALL 2009

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	JF	12/31/09	CHECKED	JF	03/12/10	136328.0500	0	FIGURE 12
DRAWN	JWR	12/31/09	APPROVED	TC	03/12/10			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGJ\FIGURE 12 mgj.dwg



LEGEND:

— — —	PJKS BOUNDARY
O&M SITE	OPERATIONS & MAINTENANCE SITE; REQUIRES ANNUAL CHECKS ON THE LIMITED COVERS AND RESTRICTS DIGGING IN THESE AREAS
SWMU	SOLID WASTE MANAGEMENT UNIT
LUC	LAND USE CONTROL

0 300 600 1200

SCALE: 1" = 600'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
A	ISSUED TO AIR FORCE	LGA	TC	

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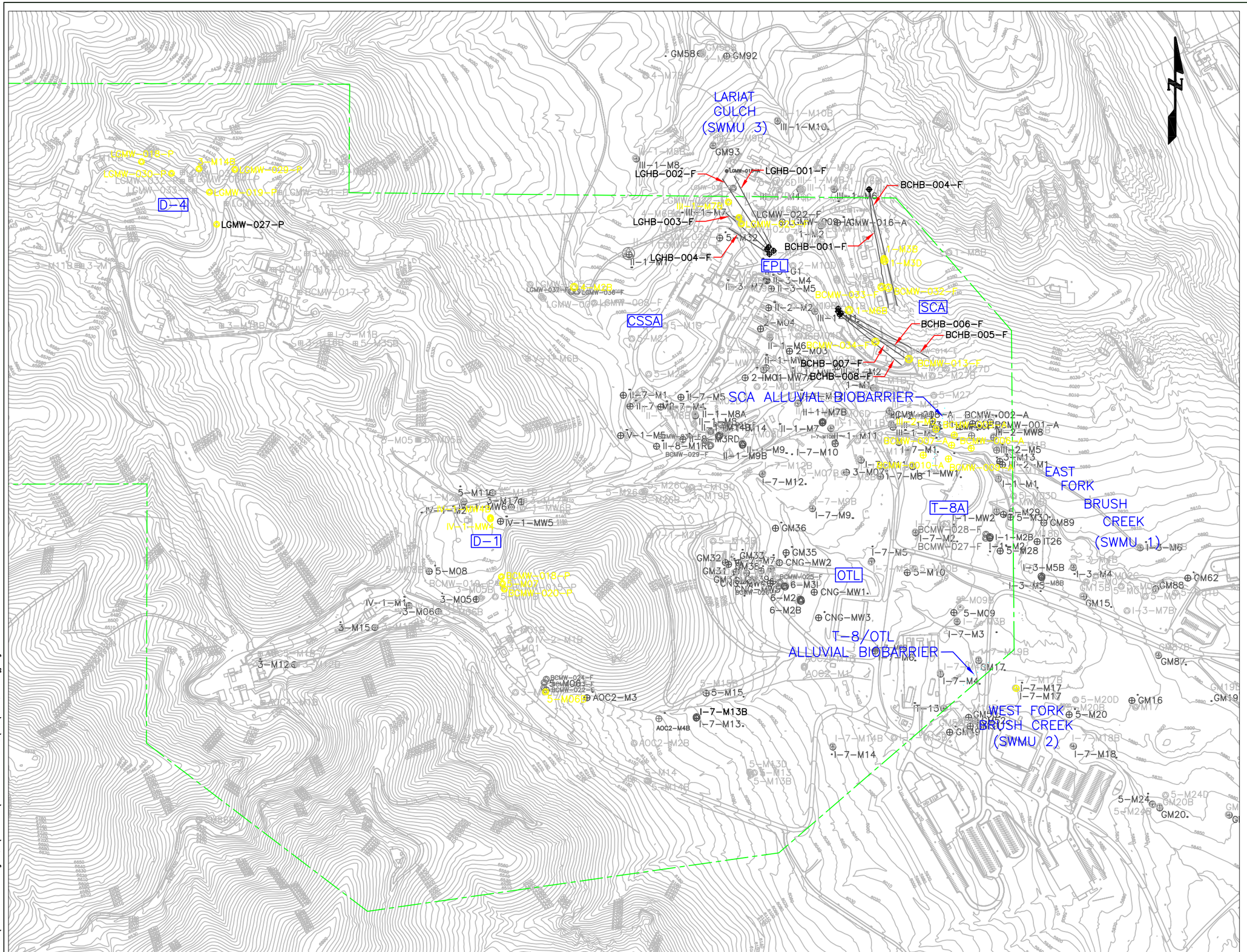
FIGURE NUMBER 13

SOIL SWMU LOCATIONS
WITH RESTRICTED CLOSURE

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DSND		06/30/10	CHKD			136328.0500	0	FIGURE 13
DRAWN		06/30/10	APPR					

K:\5590.00 Front Range PBR\AFP PJKS\Show Files\9-18-12\MGJ\FIGURE 13 MGJ.dwg



LEGEND

— — — —	PJKS BOUNDARY
BCMW-031-F	BEDROCK MONITORING WELL
BCMW-005-A	ALLUVIAL MONITORING WELL
IV-1-MW6	ALLUVIUM WELL
BCMW-011-F	FOUNTAIN WELL
3-M04B	PRECAMBRIAN WELL
	EXISTING MONITORING WELL
	DIRECTIONAL INJECTION WELL CLUSTER
SWMU	SOLID WASTE MANAGEMENT UNIT
CSSA	SOURCE AREAS

0 250 500 1000

SCALE: 1" = 500'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AGENCIES	LGA	TC	

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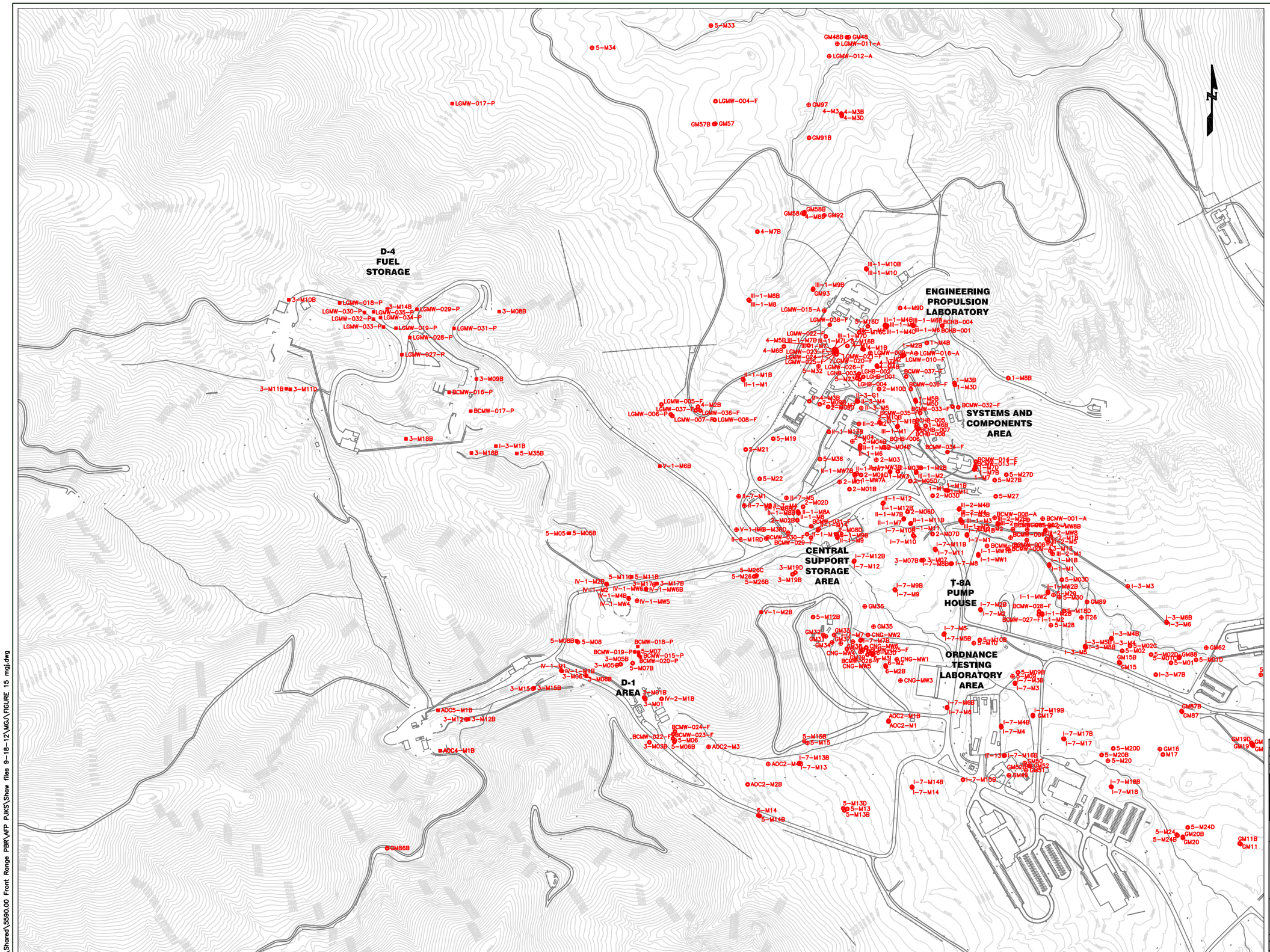
FIGURE NUMBER 14

INTERIM CORRECTIVE MEASURES, DIRECTIONAL AND VERTICAL INJECTION WELLS, PERFORMANCE MONITORING WELLS, AND BIOBARRIER LOCATIONS

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	LGA	7/2/10	CHECKED			136328.0500	0	FIGURE 14
DRAWN	TC	7/2/10	APPROVED					

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Shaw files 9-18-12\MGJ\FIGURE 14 mgj.dwg



LEGEND

⊞ V-1-M6B	PRECAMBRIAN GROUNDWATER MONITORING WELL
⊗ 5-M21	FOUNTAIN GROUNDWATER MONITORING WELL
⊕ 5-M32	ALLUVIAL GROUNDWATER MONITORING WELL
—·—·—	PJKS BOUNDARY

0 600 1200
SCALE: 1" = 600'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AIR FORCE	LGA	TC	

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FORMER AIR FORCE PLANT PJKS

FIGURE NUMBER 15

VERTICAL GROUNDWATER MONITORING WELL NETWORK

	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	EK	07/20/09	CHECKED	EK	07/20/09	136328.0500	0	FIGURE 15
DRAWN	MEC	07/20/09	APPROVED	TC	07/20/09			

K:\Shared\5590.00 Front Range PBR\AFP PJKS\Show files 9-18-12\MGJ\FIGURE 15 mgj.dwg

Appendix A
Responsiveness Summary

Appendix A

PART 3: Responsiveness Summary

RESPONSIVENESS SUMMARY

FOR

PROPOSED PLAN

FORMER AIR FORCE PLANT PJKS

WATERTON CANYON, COLORADO

OVERVIEW

This Responsiveness Summary was prepared to document and respond to issues and comments raised by the public regarding the Proposed Plan for PJKS. The preferred alternative is In-Situ Bioremediation with Environmental Covenants for contaminated groundwater. The preferred alternatives for soils are Unrestricted Closure, Restricted Closure with LUCs, and Restricted Closure with LUCs and Limited Covers.

A public meeting was held on February 8, 2012 at the Peak, Foothills Park and Recreation District, 6612 South Ward Street in Littleton, Colorado to present the preferred alternatives to the public. Comments were received during the public comment period, which began on January 12, 2012 and ended on February 25, 2012.

This Responsiveness Summary documents includes the following sections:

* Background on recent community involvement,

* Summary of comments received during the public comment period and response, and

* Remaining concerns.

BACKGROUND ON RECENT COMMUNITY INVOLVEMENT

The RAB has been involved with the discussions regarding remedies for PJKS since 1990.

The Proposed Plan for the remedy at PJKS was published in December 2011 and describes the preferred cleanup alternatives for PJKS. Based upon consideration of the NCP criteria, the appropriate remedies for PJKS are listed as follow:

* PJKS, Groundwater Alternative 2 – In-Situ Bioremediation with Environmental Covenants

* PJKS, Soil Unrestricted Closure

* PJKS, Soil Restricted Closure with LUCs

* PJKS, Soil Restricted Closure with LUCs and Limited Covers

SUMMARY OF COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND RESPONSE

There were no oral comments received at the February 2012 Public Meeting. This Section provides a summary of the comments regarding the Proposed Plan and was completed after the Public Meeting and public review comment period. Additionally, taking into consideration the stakeholder comments, the final Selected Remedies for the three SWMUs (SWMU 1 (SS034), SWMU 2 (SS021), and SWMU 3 (SS022)) are listed.

Stakeholder Comments and Lead Agency Responses

No comments from the EPA or CDPHE were submitted during the public comment period. One written comment from the public was submitted during the public comment period from 12 January 2012 to 25 February 2012, included in Appendix A. No oral comments were made during the Public Meeting. A transcript of the public meeting is provided in Appendix D.

Written Comments to the Proposed Plan

During the public comment period from 12 January 2012 to 25 February 2012, one written comment from the general public was received regarding the long-term water quality impacts to Brush Creek and Chatfield Reservoir. The written comment submitted during the public comment period is included in Appendix D.

Written Comment 1 (Chatfield Watershed Authority)

Ms. Julie Vlier, representing the Chatfield Watershed Authority, mentions that it is unclear if the proposed monitoring program ensures protection of the Chatfield watershed and its reservoir. Ms. Vlier also states that the Chatfield Watershed Authority is “concerned that contaminated waters may not have yet reached portions of the Chatfield system. The Authority

believes that funding to monitor water quality is necessary to confirm that there indeed are no water quality problems".

Air Force Response to Written Comment 1

The Air Force understands the Chatfield Watershed Authority's concern. Twenty plus years of PJKS specific monitoring data has shown that groundwater contamination created by PJKS activities has not migrated beyond the boundaries of the LMSSC facility that completely surrounds PJKS. There is also evidence that the PJKS plumes are stable and contamination is not migrating further downgradient from the source areas. The discharge of contaminated groundwater to surface streams does not result in an exceedence of State of Colorado Basic Standards for Surface Water. Thus, there is no threat to the environment via the transfer of contaminants from groundwater to surface water exposure scenario.

The groundwater contamination created by PJKS activities has not migrated beyond the boundaries of the LMSSC facility that completely surrounds PJKS. Further, the groundwater at PJKS that is moving onto surrounding Lockheed Martin property is intercepted by Lockheed Martin, which treats groundwater coming off of its property before it gets to the South Platte River. While the Lockheed Martin remediation system was not installed to remediate PJKS sourced groundwater contamination, Lockheed Martin will be required to continue to operate the groundwater remediation system under a State of Colorado Hazardous Waste Corrective Action Order as long as groundwater contamination exists on their property, even if the contamination is sourced from PJKS.

Denver Water also regularly analyzes surface water samples from Chatfield Reservoir and has never detected concentrations that exceed the State of Colorado Basic Standards for drinking water.

Selected Remedies

After careful consideration, the Air Force, with concurrence of EPA and CDPHE, have selected the following final remedies for the three SWMUs (SWMU 1 (SS034), SWMU 2 (SS021), and SWMU 3 (SS022) :

Alternative 2 – In-Situ Bioremediation and Environmental Covenants. Alternative 2 is recommended because it provides high levels of overall protection of human health by controlling and restricting access to the site and limiting potential exposure to groundwater.

Technical and Legal Issues

There are no technical or legal issues associated with the recommendation of the Selected Remedies for OU-4 Site SS022 or OU-5 Sites ST034, and SS021 at the time of this publication.

REMAINING CONCERNS

Based on review of the comments received during the public meeting and public comment period, there are no outstanding issues associated with implementation of the proposed remedial actions.

Appendix B
Attenuation Calculations

Asymptotic Decision

To demonstrate that asymptotic conditions have been achieved at the bedrock source areas, a minimum of 2 sampling event results collected from specific compliance monitoring/performance monitoring wells over at least a 2-year period will be required. Statistical analysis of the data may be used to aid in the demonstration of asymptotic conditions. The U.S. Environmental Protection Agency (EPA) document titled *Statistical Methods for Evaluating Cleanup Standards: Volume II, Ground Water (EPA 230-R-92-014)* along with a least squares analysis of the exponential fit of the data and the Mann-Kendall test to measure the temporal trend of the data will be considered.

The Air Force, CDPHE, and EPA will review the data and determine whether asymptotic trends have been achieved and, as a result, the COC concentrations have been reduced as much as is technically practicable. Once an agreement has been established that a plateau has been reached, the operation of the active remedy will be complete and will be terminated. A long-term monitoring program and continued compliance with the conditions of the Environmental Covenant will be identified as the alternative remedial strategy to protect human health and the environment once asymptotic conditions have been reached.

PJKS TCE Source Area Treatment

Source Area	Groundwater Well	2006 Pre-ICM TCE Concentration (µg/L)	Groundwater Well	2009 Post-ICM TCE Maximum Concentrations (µg/L)	Time required to reduce bedrock source area to concentration at transition point (µg/L)	Distance from source area transition point (into alluvium) to property boundary (feet)	TCE concentration needed for natural attenuation to achieve CBSG at property boundary (µg/L)	Revised time (based on current D-1 data) required to reduce bedrock source area to concentration at transition point (µg/L)	Revised time (based on current D-1 data and Sept. 09 data) required to reduce bedrock source area to concentration at transition point (µg/L)
EPL	III-1-M7B	6,600	LGMW-022-F	11,000	49 months	0 (N)	5	87 months	94 months
					11 months	1400 (SE)	600	30 months	35 months
SCA	1-M3D	1,700 (N)	1-M3D	1,600	40 months	0 (N)	5	71 months	
	BCMW-014-F	10,000 (SE)	BCMW-014-F	9,100*	31 months	700 (SE)	60	63 months	
D-1	BCMW-015-P	7,200	BCMW-020-P	6,000	0 months	2700 (N)	>20,000	0 months	
					0 months	2000 (SE)	4,700	0 months	
CSSA	II-1-M14B	460	II-1-M14B	170	25 months	200 (N)	15	43 months	32 months
					0 months	1200 (SE)	200	0 months	
OTL	6-M3I	140	6-M2B	12	0 months	900	120	0 months	
T-8A	I-1-M2B	190	I-1-M2B	180	25 months	0 (N)	5	45 months	
					14 months	400 (SE)	25	24 months	

Note:
*SCA data from August 2008 (BCMW-014-F no longer sampled as part of Performance Monitoring)
2006 TCE values
(N) = north, meaning groundwater flow towards the northern PJKS boundary
(SE) = southeast, meaning groundwater flow towards the southeastern PJKS boundary
Pre-ICM = prior to the start of the Interim Corrective Measures at the source areas
CBSG = Colorado Basic Standards for Groundwater (TCE = 5 µg/L)
µg/L = micrograms per liter

This is a brief explaination of the derivation of source area concentrations required to achieve the Colorado Basic Standards for Groundwater (CBSG) for groundwater as it crosses from the PJKS property boundary to the Lockheed Martin property. In order to evaluate the fate and transport of the groundwater contamination from six source areas at PJKS, a series of best fit regression curves have been used. Following the conceptual site model for PJKS, groundwater flows from bedrock source areas into the alluvial groundwater (Figure B-1). Since the D-4 source area has no apparent connection into the alluvial groundwater aquifer, this area is not considered for this evaluation. TCE fate and transport have different properties in the associated groundwater aquifer. Therefore, two scenarios were used to show a comprehensive history of TCE groundwater flow from treatment at the bedrock source area to natural attenuation in the alluvium where CBSGs are calculated to be achieved.

The source area concentrations were calculated in 2 steps using actual data from TCE attenuation in alluvium and TCE degradation in a bedrock source area. First data was used from TCE attenuation in East Fork Brush Creek alluvial groundwater to plot the regression for distance at the TCE transition point (from bedrock to alluvium) and the concentration to achieve CBSGs through natural attenuation. The approximate distance of the transition crossover points from the Bedrock groundwater to the alluvium is shown on Figure B-2. Then data was used from TCE degradation at the D-1 bedrock source area to plot regression of length of time to achieve the transition point concentration (plotted in first step).

Alluvial Attenuation

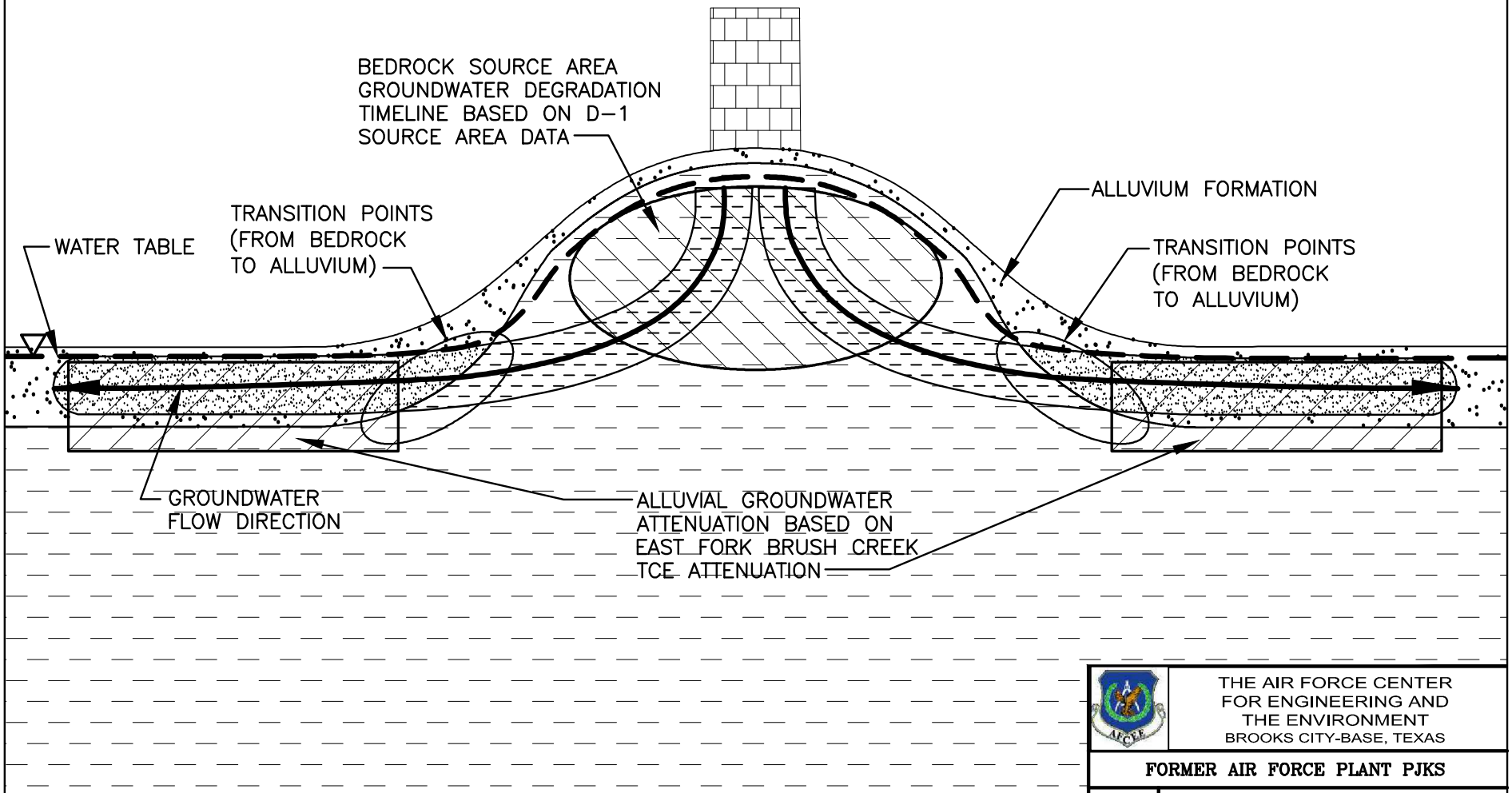
Exponential best fit regression curves from actual PJKS alluvium groundwater data has allowed the projection of the distance and concentrations. The exponential curves exhibit good correction with R^2 values of 0.8188 (East Fork Brush Creek Alluvial Attenuation). Reduction curve illustrates the natural attenuation of TCE in the alluvial aquifer of real and projected concentrations over various distances. This curve shows TCE concentrations versus distance (feet). The exponential line has been projected back to calculate distance at increasing TCE concentrations (that would represent the transition point values).

Bedrock Degradation

Exponential best fit regression curves from actual PJKS bedrock groundwater data has allowed the projection of the time and decreasing TCE concentrations. The exponential curves exhibit good correction with R^2 values of 0.8011 (D-1 Biodegradation Source Reduction). Reduction curve illustrates the effectiveness of biodegradation of a TCE source in a Pre-cambrian aquifer of real and projected data over a period of several years. This curve shows TCE concentrations versus increasing time (months, years). The exponential line has been projected out until October 2010, where the source area will have achieved the CBSG for TCE of 5 μg/L.

Each source area was plotted on both the concentration vs. time (where source area biodegradation would be employed) and concentration vs. distance (where natural

attenuation of the plume is assumed). These plots allowed for the source areas to be plotted along the best fit curve and therefore frames for biodegradation and distances for natural attenuation could be inferred from the existing regression lines. In turn, the optimal source area concentration (where the CBSG for TCE is achieved at the PJKS property boundary) could be interpreted and extrapolated.



BEDROCK DEGRADATION

ALLUVIAL ATTENUATION

REVISION	DESCRIPTION	CHKD	APPR	DATE
0	ISSUED TO AGENCIES	LGA	TC	

	BY	DATE		BY	DATE		BY	DATE		BY	DATE
DSGN	TC	12/31/09	DRAWN	JWR	12/31/09	CHKD	TC	03/12/10	APPR	TC	03/12/10

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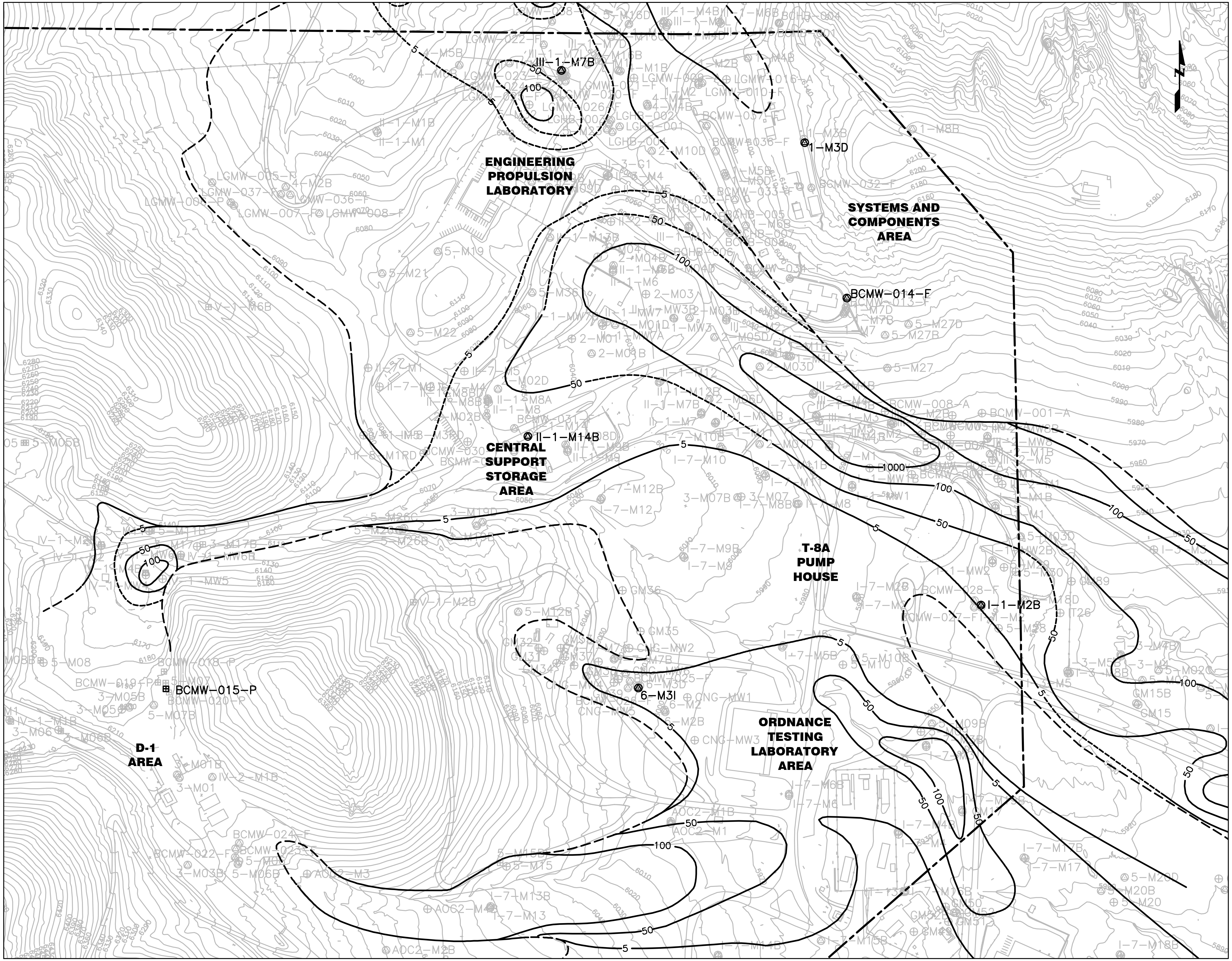
FIGURE NUMBER B–1

ATTENUATION MODEL

Shaw Environmental, Inc.

PROJECT NO.	REV.	FILE NAME
136328.0500	0	FIGURE B-1

D:\136328\0500\FIGURE B-1.dwg



LEGEND

⊞ V-1-M6B PRECAMBRIAN GROUNDWATER MONITORING WELL

⊚ 5-M21 FOUNTAIN GROUNDWATER MONITORING WELL

⊕ 5-M32 ALLUVIAL GROUNDWATER MONITORING WELL

PJKS BOUNDARY

EXTENT OF SATURATED ALLUVIUM (DASHED WHERE INFERRED)

TCE CONCENTRATION CONTOUR (DASHED WHERE INFERRED)

TCE CONCENTRATION CONTOURS IN μg/L

0 300 600

SCALE: 1" = 300'

REVISION	DESCRIPTION	CHECKED	APPROVED	DATE
0	ISSUED TO AIR FORCE	LGA	TC	

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BROOKS CITY-BASE, TEXAS

FORMER AIR FORCE PLANT PJKS

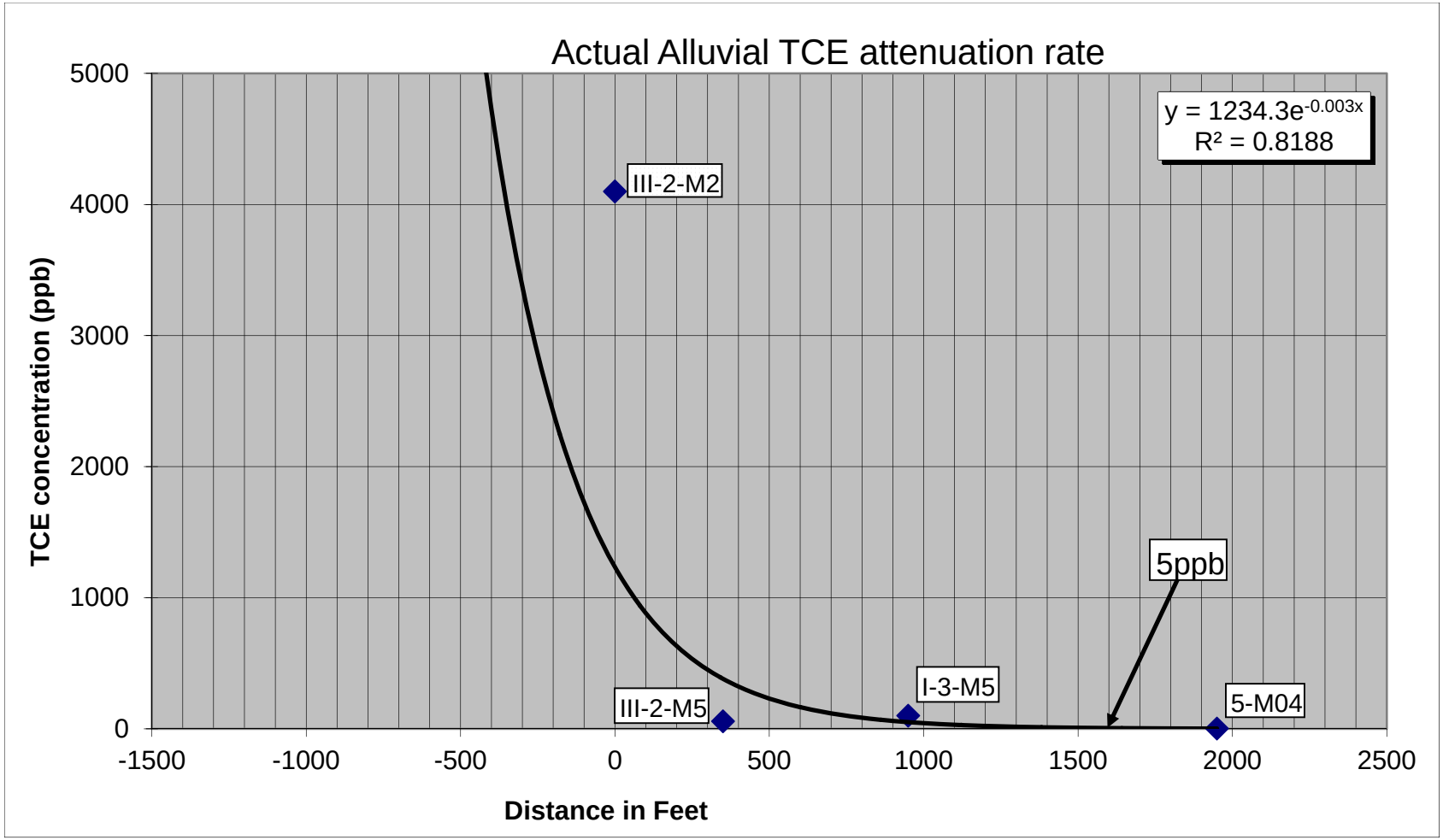
FIGURE NUMBER B-2

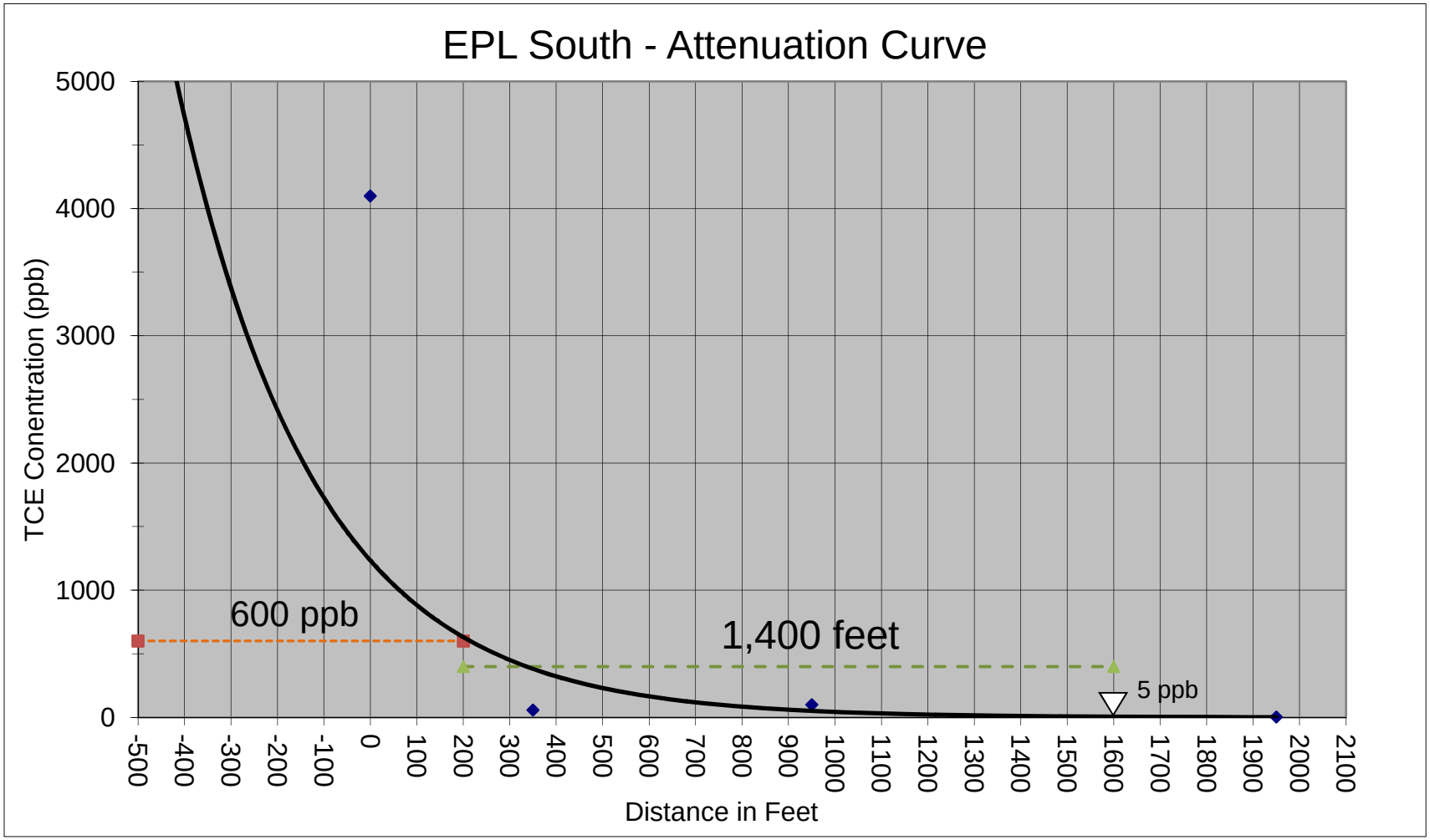
SOURCE AREA WELLS USED FOR ATTENUATION CALCULATION

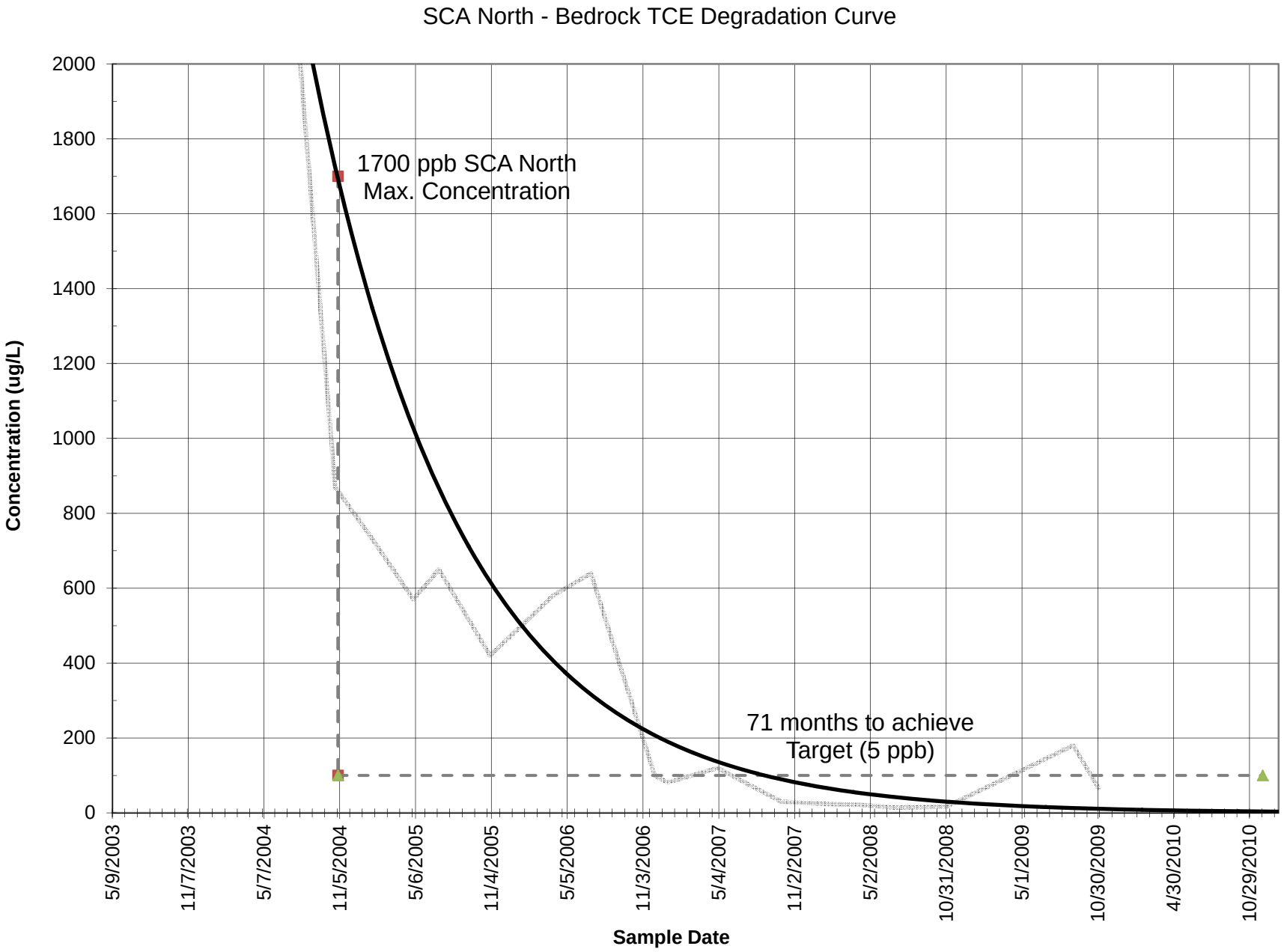
Shaw Environmental, Inc.

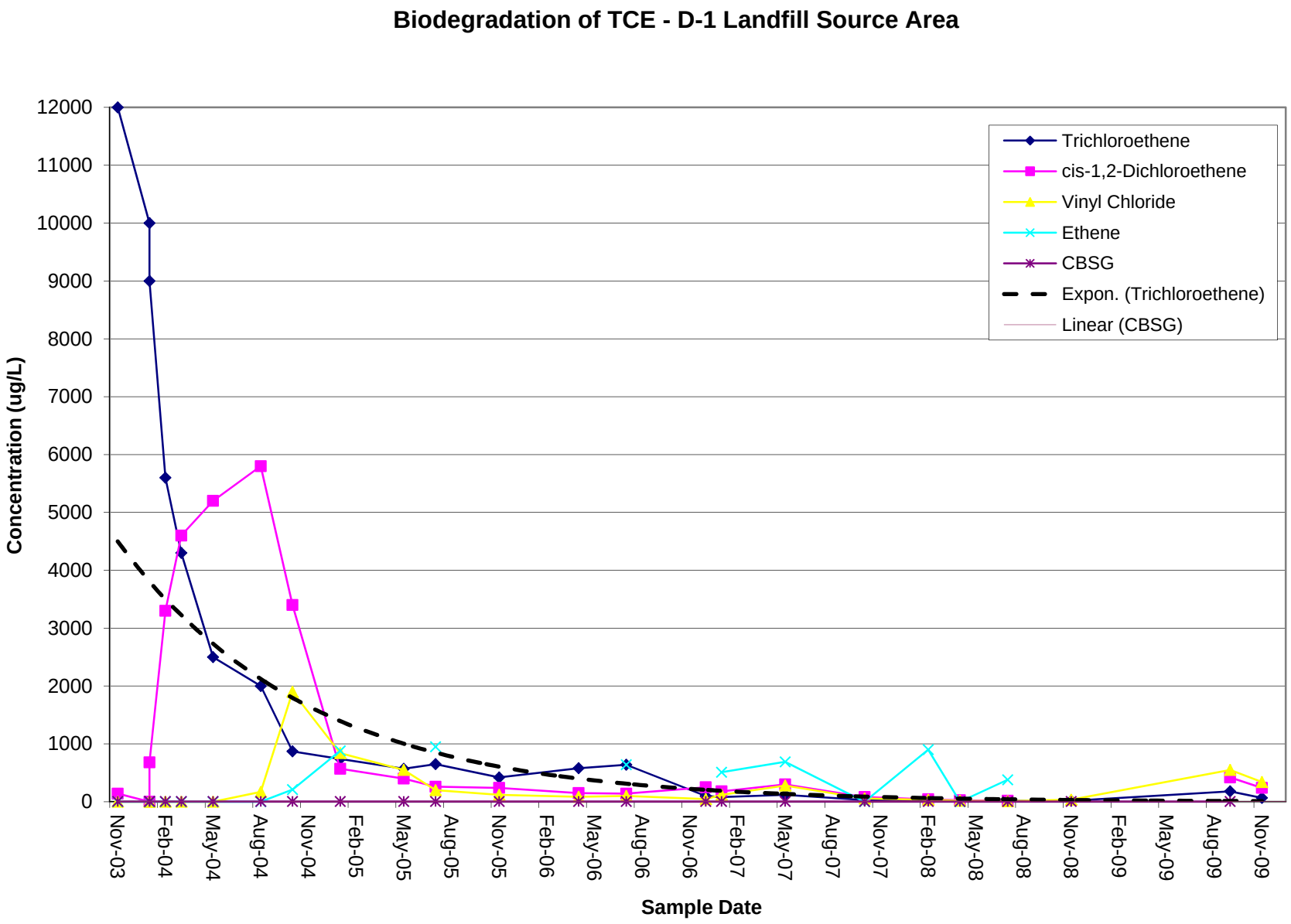
	BY	DATE		BY	DATE	PROJECT NO.	REV.	FILE NAME
DESIGNED	EK	07/20/09	CHECKED	EK	07/20/09	136328.0500	0	FIGURE B-2
DRAWN	MEC	07/20/09	APPROVED	TC	07/20/09			

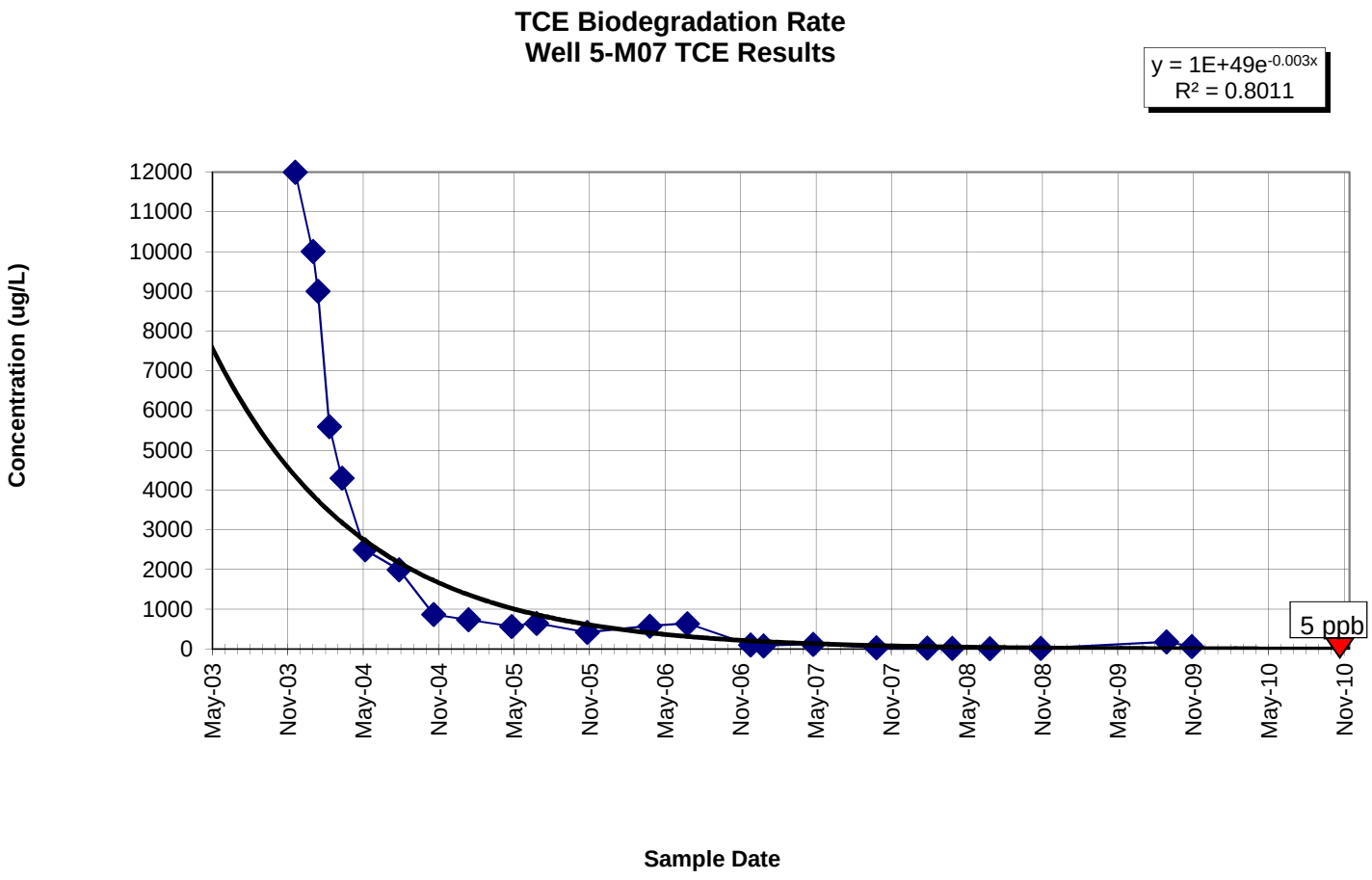
D:\136328\0500\FIGURE B-2.dwg


Actual Alluvial TCE attenuation rate
y = 1234.3e-0.003x
R² = 0.8188
III-2-M2
III-2-M5
I-3-M5
5-M04
5ppb
TCE concentration (ppb)
5000
4000
3000
2000
1000
0
-1500
-1000
-500
0
500
1000
1500
2000
2500
Distance in Feet


EPL South - Attenuation Curve
TCE Conentration (ppb)
5000
4000
3000
2000
1000
0
600 ppb
1,400 feet
5 ppb
-500
-400
-300
-200
-100
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
Distance in Feet


SCA North - Bedrock TCE Degradation Curve
1700 ppb SCA North
Max. Concentration
71 months to achieve
Target (5 ppb)
Concentration (ug/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
5/9/2003
11/7/2003
5/7/2004
11/5/2004
5/6/2005
11/4/2005
5/5/2006
11/3/2006
5/4/2007
11/2/2007
5/2/2008
10/31/2008
5/1/2009
10/30/2009
4/30/2010
10/29/2010
Sample Date


Biodegradation of TCE - D-1 Landfill Source Area
Concentration (ug/L)
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Nov-03
Feb-04
May-04
Aug-04
Nov-04
Feb-05
May-05
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Sample Date
Trichloroethene
cis-1,2-Dichloroethene
Vinyl Chloride
Ethene
CBSG
Expon. (Trichloroethene)
Linear (CBSG)


TCE Biodegradation Rate
Well 5-M07 TCE Results
y = 1E+49e-0.003x
R² = 0.8011
Concentration (ug/L)
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
5 ppb
May-03
Nov-03
May-04
Nov-04
May-05
Nov-05
May-06
Nov-06
May-07
Nov-07
May-08
Nov-08
May-09
Nov-09
May-10
Nov-10
Sample Date

Appendix C
Cost Summary for Alternative 2

Technology Detail Report
(with Markups)

Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8150
Email Address: lindsay.archibald@shawgrp.com
Estimate Prepared Date: 06/01/2010

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Thomas Cooper
Reviewer Title: Project Manager
Agency/Org./Office: Shaw
Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8163
Email Address: thomas.cooper@shawgrp.com
Date Reviewed: 06/01/2010

Reviewer Signature: _____ **Date:** _____

This report for official U.S. Government use only.

Technology Detail Report
(with Markups)

Phase:

Phase Type: Long Term Monitoring
Phase Name: LTM
Description: This is the cost estimate for LTM for the life of the project for the FFS, for in-situ bioremediation and monitoring and 5-year reviews.

Start Date: June, 2010
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING	Yes	100	0
Five-Year Review	Yes	100	0
ADMINISTRATIVE LAND USE CONTROLS	Yes	100	0
FINAL ROUND OF INJECTIONS	Yes	100	0
MONITORING	Yes	100	0

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Technology Detail Report
(with Markups)

Technology:

Name: FINAL ROUND OF INJECTIONS
Prime Markup: 100 %
Sub Markup: 0 %
Comments: This estimate accounts for the injection of EEO into 32 vertical wells and 10 horizontal wells.

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	SubBid Unit Cost	Extended Cost	Cost Override	Markups Applied
33010109	Truck, 2 Axle, Highway, 21,700 GVW, 4 x 2, 2 Axle	60.00	DAY	0.00	0.00	388.81	0.00	$23,328.41	☐	☑
33190149	Truck Driver, Light	600.00	HR	0.00	92.80	0.00	0.00	$55,679.46	☐	☑
33220105	Project Engineer	100.00	HR	0.00	157.36	0.00	0.00	$15,736.14	☐	☑
33220109	Staff Scientist	1,000.00	HR	0.00	102.32	0.00	0.00	$102,321.25	☐	☑
33220112	Field Technician	1,000.00	HR	0.00	106.04	0.00	0.00	$106,039.09	☐	☑
33330184	Emulsified Vegetable Oil Bioremediation Substrate	13,000.00	LB	3.16	0.00	0.00	0.00	$41,103.86	☐	☑

Total Technology Cost **$344,208.20**

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

System:

RACER Version: 10.3.0
Database Location: T:\E&I_Projects\AFCEE\4P\PJKS-4P\Eng\Racer\PJKS FFS.mdb

Folder:

Folder Name: PJKS FFS

Project:

Project ID: PJKS FFS
Project Name: Cost Estimate for FFS
Project Category: None

Location
State / Country: COLORADO
City: COLORADO STATE AVERAGE

Location Modifier	Default	User
	1.000	1.000

Options
Database: Modified System
Cost Database Date: 2010
Report Option: Fiscal

Description These are the cost estimates for the Focused Feasibility Study for PJKS.

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Site:

Site ID: Alternative 2
Site Name: In situ Bioremediation
Site Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study: ☐
PA, SI, PA/SI, RI, FS, RI/FS: ☐
RD: ☐
IRA-C: ☐
RA-C: ☐
IRA-O, RA-O: ☐
LTM: ☑
PCO: ☐

Documentation

Description: This is the cost estimate for Alternative 2, In Situ Bioremediation for the FFS.
Support Team: ASC/ENVR, AFCEE, and Shaw E&I
References: Feasibility Study, Former Air Force Plant PJKS, June 2010

Estimator Information

Estimator Name: Lindsay Archibald
Estimator Title: Geologist
Agency/Org./Office: Shaw

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8150
Email Address: lindsay.archibald@shawgrp.com
Estimate Prepared Date: 06/01/2010

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Thomas Cooper
Reviewer Title: Project Manager
Agency/Org./Office: Shaw
Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8163
Email Address: thomas.cooper@shawgrp.com
Date Reviewed: 06/01/2010

Reviewer Signature: _____ **Date:** _____

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Phase:

Phase Type: Long Term Monitoring
Phase Name: LTM
Description: This is the cost estimate for LTM for the life of the project for the FFS, for in-situ bioremediation and monitoring and 5-year reviews.

Start Date: June, 2010
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING YEAR 0-5	Yes	100	0
Five-Year Review	Yes	100	0
ENVIRONMENTAL COVENANT	Yes	100	0
FINAL ROUND OF INJECTIONS	Yes	100	0
MONITORING YEAR 6-30	Yes	100	0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

	2015	2016	2017	2018	2019	2020
Document Review	$6,215	$0	$0	$0	$0	$6,215
Site Inspection	$2,462	$0	$0	$0	$0	$2,462
Report	$8,566	$0	$0	$0	$0	$8,566
Total Technology Cost	$17,243	$0	$0	$0	$0	$17,243

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

	2021	2022	2023	2024	2025	2026
Document Review	$0	$0	$0	$0	$6,215	$0
Site Inspection	$0	$0	$0	$0	$2,462	$0
Report	$0	$0	$0	$0	$8,566	$0
Total Technology Cost	$0	$0	$0	$0	$17,243	$0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

	2027	2028	2029	2030	2031	2032
Document Review	$0	$0	$0	$6,215	$0	$0
Site Inspection	$0	$0	$0	$2,462	$0	$0
Report	$0	$0	$0	$8,566	$0	$0
Total Technology Cost	$0	$0	$0	$17,243	$0	$0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

	2033	2034	2035	2036	2037	2038
Document Review	$0	$0	$6,215	$0	$0	$0
Site Inspection	$0	$0	$2,462	$0	$0	$0
Report	$0	$0	$8,566	$0	$0	$0
Total Technology Cost	$0	$0	$17,243	$0	$0	$0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Five-Year Review
Prime Markup: 100 %
Sub Markup: 0 %

	2039	2040	Total
Document Review	$0	$6,215	$37,288
Site Inspection	$0	$2,462	$14,772
Report	$0	$8,566	$51,399
Total Technology Cost	$0	$17,243	$103,459

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

System:

RACER Version: 10.3.0
Database Location: T:\E&I_Projects\AFCEE\4P\PJKS-4P\Eng\Racer\PJKS FFS.mdb

Folder:

Folder Name: PJKS FFS

Project:

Project ID: PJKS FFS
Project Name: Cost Estimate for FFS
Project Category: None

Location
State / Country: COLORADO
City: COLORADO STATE AVERAGE

Location Modifier	Default	User
	1.000	1.000

Options
Database: Modified System
Cost Database Date: 2010
Report Option: Fiscal

Description These are the cost estimates for the Focused Feasibility Study for PJKS.

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Site:

Site ID: Alternative 2
Site Name: In situ Bioremediation
Site Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study: ☐
PA, SI, PA/SI, RI, FS, RI/FS: ☐
RD: ☐
IRA-C: ☐
RA-C: ☐
IRA-O, RA-O: ☐
LTM: ☑
PCO: ☐

Documentation

Description: This is the cost estimate for Alternative 2, In Situ Bioremediation for the FFS.
Support Team: ASC/ENVR, AFCEE, and Shaw E&I
References: Feasibility Study, Former Air Force Plant PJKS, June 2010

Estimator Information

Estimator Name: Lindsay Archibald
Estimator Title: Geologist
Agency/Org./Office: Shaw

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Technology Cost Over Time Report
(with Markups)

Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8150
Email Address: lindsay.archibald@shawgrp.com
Estimate Prepared Date: 06/01/2010

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Thomas Cooper
Reviewer Title: Project Manager
Agency/Org./Office: Shaw
Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8163
Email Address: thomas.cooper@shawgrp.com
Date Reviewed: 06/01/2010

Reviewer Signature: _____ **Date:** _____

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Phase:

Phase Type: Long Term Monitoring
Phase Name: LTM
Description: This is the cost estimate for LTM for the life of the project for the FFS, for in-situ bioremediation and monitoring and 5-year reviews.

Start Date: June, 2010
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING YEAR 0-5	Yes	100	0
Five-Year Review	Yes	100	0
ENVIRONMENTAL COVENANT	Yes	100	0
FINAL ROUND OF INJECTIONS	Yes	100	0
MONITORING YEAR 6-30	Yes	100	0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	2010	2011	2012	2013	2014	2015
Groundwater	$35,556	$35,556	$35,556	$35,556	$35,556	$35,556
Data Management	$36,947	$11,095	$11,095	$11,095	$11,095	$11,095
General Monitoring	$2,470	$2,470	$2,470	$2,470	$2,470	$2,470
Total Technology Cost	$74,973	$49,121	$49,121	$49,121	$49,121	$49,121

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	Total
Groundwater	$213,337
Data Management	$92,421
General Monitoring	$14,822
Total Technology Cost	$320,581

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

System:

RACER Version: 10.3.0
Database Location: T:\E&I_Projects\AFCEE\4P\PJKS-4P\Eng\Racer\PJKS FFS.mdb

Folder:

Folder Name: PJKS FFS

Project:

Project ID: PJKS FFS
Project Name: Cost Estimate for FFS
Project Category: None

Location
State / Country: COLORADO
City: COLORADO STATE AVERAGE

Location Modifier	Default	User
	1.000	1.000

Options
Database: Modified System
Cost Database Date: 2010
Report Option: Fiscal

Description These are the cost estimates for the Focused Feasibility Study for PJKS.

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Site:

Site ID: Alternative 2
Site Name: In situ Bioremediation
Site Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study: ☐
PA, SI, PA/SI, RI, FS, RI/FS: ☐
RD: ☐
IRA-C: ☐
RA-C: ☐
IRA-O, RA-O: ☐
LTM: ☑
PCO: ☐

Documentation

Description: This is the cost estimate for Alternative 2, In Situ Bioremediation for the FFS.
Support Team: ASC/ENVR, AFCEE, and Shaw E&I
References: Feasibility Study, Former Air Force Plant PJKS, June 2010

Estimator Information

Estimator Name: Lindsay Archibald
Estimator Title: Geologist
Agency/Org./Office: Shaw

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Technology Cost Over Time Report
(with Markups)

Business Address: 7604 Technology Way
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Telephone Number: 720-554-8150
Email Address: lindsay.archibald@shawgrp.com
Estimate Prepared Date: 06/01/2010

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Thomas Cooper
Reviewer Title: Project Manager
Agency/Org./Office: Shaw
Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8163
Email Address: thomas.cooper@shawgrp.com
Date Reviewed: 06/01/2010

Reviewer Signature: _____ **Date:** _____

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Phase:

Phase Type: Long Term Monitoring
Phase Name: LTM
Description: This is the cost estimate for LTM for the life of the project for the FFS, for in-situ bioremediation and monitoring and 5-year reviews.

Start Date: June, 2010
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING YEAR 0-5	Yes	100	0
Five-Year Review	Yes	100	0
ENVIRONMENTAL COVENANT	Yes	100	0
FINAL ROUND OF INJECTIONS	Yes	100	0
MONITORING YEAR 6-30	Yes	100	0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	2010	2011	2012	2013	2014	2015
Groundwater	$19,818	$19,818	$19,818	$19,818	$19,818	$19,818
Data Management	$21,642	$7,597	$7,597	$7,597	$7,597	$7,597
General Monitoring	$1,918	$1,918	$1,918	$1,918	$1,918	$1,918
Total Technology Cost	$43,379	$29,333	$29,333	$29,333	$29,333	$29,333

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	2016	2017	2018	2019	2020	2021
Groundwater	$19,818	$19,818	$19,818	$19,818	$19,818	$19,818
Data Management	$7,597	$7,597	$7,597	$7,597	$7,597	$7,597
General Monitoring	$1,918	$1,918	$1,918	$1,918	$1,918	$1,918
Total Technology Cost	$29,333	$29,333	$29,333	$29,333	$29,333	$29,333

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	2022	2023	2024	2025	2026	2027
Groundwater	$19,818	$19,818	$19,818	$19,818	$19,818	$19,818
Data Management	$7,597	$7,597	$7,597	$7,597	$7,597	$7,597
General Monitoring	$1,918	$1,918	$1,918	$1,918	$1,918	$1,918
Total Technology Cost	$29,333	$29,333	$29,333	$29,333	$29,333	$29,333

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	2028	2029	2030	2031	2032	2033
Groundwater	$19,818	$19,818	$19,818	$19,818	$19,818	$19,818
Data Management	$7,597	$7,597	$7,597	$7,597	$7,597	$7,597
General Monitoring	$1,918	$1,918	$1,918	$1,918	$1,918	$1,918
Total Technology Cost	$29,333	$29,333	$29,333	$29,333	$29,333	$29,333

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Monitoring

Templates:
System Water - VOCs

Prime Markup: 100 %
Sub Markup: 0 %

	2034	2035	Total
Groundwater	$19,818	$19,818	$515,278
Data Management	$7,597	$7,597	$211,564
General Monitoring	$1,918	$1,918	$49,868
Total Technology Cost	$29,333	$29,333	$776,710

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

System:

RACER Version: 10.3.0
Database Location: T:\E&I_Projects\AFCEE\4P\PJKS-4P\Eng\Racer\PJKS FFS.mdb

Folder:

Folder Name: PJKS FFS

Project:

Project ID: PJKS FFS
Project Name: Cost Estimate for FFS
Project Category: None

Location
State / Country: COLORADO
City: COLORADO STATE AVERAGE

Location Modifier	Default	User
	1.000	1.000

Options
Database: Modified System
Cost Database Date: 2010
Report Option: Fiscal

Description These are the cost estimates for the Focused Feasibility Study for PJKS.

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Site:

Site ID: Alternative 2
Site Name: In situ Bioremediation
Site Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study: ☐
PA, SI, PA/SI, RI, FS, RI/FS: ☐
RD: ☐
IRA-C: ☐
RA-C: ☐
IRA-O, RA-O: ☐
LTM: ☑
PCO: ☐

Documentation

Description: This is the cost estimate for Alternative 2, In Situ Bioremediation for the FFS.
Support Team: ASC/ENVR, AFCEE, and Shaw E&I
References: Feasibility Study, Former Air Force Plant PJKS, June 2010

Estimator Information

Estimator Name: Lindsay Archibald
Estimator Title: Geologist
Agency/Org./Office: Shaw

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8150
Email Address: lindsay.archibald@shawgrp.com
Estimate Prepared Date: 06/01/2010

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Thomas Cooper
Reviewer Title: Project Manager
Agency/Org./Office: Shaw
Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8163
Email Address: thomas.cooper@shawgrp.com
Date Reviewed: 06/01/2010

Reviewer Signature: _____ **Date:** _____

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Phase:

Phase Type: Long Term Monitoring
Phase Name: LTM
Description: This is the cost estimate for LTM for the life of the project for the FFS, for in-situ bioremediation and monitoring and 5-year reviews.

Start Date: June, 2010
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING YEAR 0-5	Yes	100	0
Five-Year Review	Yes	100	0
ENVIRONMENTAL COVENANT	Yes	100	0
FINAL ROUND OF INJECTIONS	Yes	100	0
MONITORING YEAR 6-30	Yes	100	0

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Administrative Land Use Controls
Prime Markup: 100 %
Sub Markup: 0 %

	2010	2011	2012	2013	2014	2015
Monitoring & Enforcement	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710
Total Technology Cost	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Administrative Land Use Controls
Prime Markup: 100 %
Sub Markup: 0 %

	2016	2017	2018	2019	2020	2021
Monitoring & Enforcement	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710
Total Technology Cost	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Administrative Land Use Controls
Prime Markup: 100 %
Sub Markup: 0 %

	2022	2023	2024	2025	2026	2027
Monitoring & Enforcement	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710
Total Technology Cost	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Administrative Land Use Controls
Prime Markup: 100 %
Sub Markup: 0 %

	2028	2029	2030	2031	2032	2033
Monitoring & Enforcement	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710
Total Technology Cost	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Administrative Land Use Controls
Prime Markup: 100 %
Sub Markup: 0 %

	2034	2035	2036	2037	2038	2039
Monitoring & Enforcement	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710
Total Technology Cost	$2,710	$2,710	$2,710	$2,710	$2,710	$2,710

This report for official U.S. Government use only.

Technology Cost Over Time Report
(with Markups)

Technology:

Name: Administrative Land Use Controls
Prime Markup: 100 %
Sub Markup: 0 %

	Total
Monitoring & Enforcement	$81,300
Total Technology Cost	$81,300

This report for official U.S. Government use only.

Estimate Documentation Report

System:

RACER Version: 10.3.0
Database Location: T:\E&I_Projects\AFCEE\4P\PJKS-4P\Eng\Racer\PJKS FFS.mdb

Folder:

Folder Name: PJKS FFS

Project:

Project ID: PJKS FFS
Project Name: Cost Estimate for FFS
Project Category: None

Location
State / Country: COLORADO
City: COLORADO STATE AVERAGE

Location Modifier	Default	User
	1.000	1.000

Options
Database: Modified System
Cost Database Date: 2010
Report Option: Fiscal

Description These are the cost estimates for the Focused Feasibility Study for PJKS.

This report for official U.S. Government use only.

Estimate Documentation Report

Site Documentation:

Site ID: Alternative 2
Site Name: In situ Bioremediation
Site Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Volatile Organic Compounds (VOCs)
Secondary: None

Phase Names

Pre-Study: ☐
PA, SI, PA/SI, RI, FS, RI/FS: ☐
RD: ☐
IRA-C: ☐
RA-C: ☐
IRA-O, RA-O: ☐
LTM: ☑
PCO: ☐

Documentation

Description: This is the cost estimate for Alternative 2, In Situ Bioremediation for the FFS.
Support Team: ASC/ENVR, AFCEE, and Shaw E&I
References: Feasibility Study, Former Air Force Plant PJKS, June 2010

Estimator Information

Estimator Name: Lindsay Archibald
Estimator Title: Geologist
Agency/Org./Office: Shaw
Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8150
Email Address: lindsay.archibald@shawgrp.com
Estimate Prepared Date: 06/15/2010

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Thomas Cooper
Reviewer Title: Project Manager
Agency/Org./Office: Shaw

This report for official U.S. Government use only.

Estimate Documentation Report

Business Address: 7604 Technology Way
Suite 300
Denver, CO 80237
Telephone Number: 720-554-8163
Email Address: thomas.cooper@shawgrp.com
Date Reviewed: 06/15/2010

Reviewer Signature: _____ **Date:** _____

Estimated Costs:

Phase Names		Direct Cost	Marked-up Cost
LTM		$1,200,248	$2,349,402
	Total Cost:	$1,200,248	$2,349,402

This report for official U.S. Government use only.

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: LTM
Description: This is the cost estimate for LTM for the life of the project for the FFS, for in-situ bioremediation and monitoring and 5-year reviews and well abandonment.

Start Date: June, 2010
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING YEAR 0-5	Yes	100	0
Five-Year Review	Yes	100	0
ENVIRONMENTAL COVENANT	Yes	100	0
FINAL ROUND OF INJECTIONS	Yes	100	0
MONITORING YEAR 6-30	Yes	100	0
Well Abandonment	Yes	100	0
Well Abandonment	Yes	100	0
Well Abandonment	Yes	100	0

Total Marked-up Cost: $2,349,402

Technologies:

This report for official U.S. Government use only.

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **MONITORING YEAR 0-5**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		MONITORING YEAR 0-5	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		25	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		60	FT
Samples per Event (First Year)		50	n/a
Samples per Event (Out Years)		50	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		1	n/a
Number of Years (Out Years)		5	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	System Water - VOCs	n/a
Secondary Analytical Template	None	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 0	EA
Field Duplicate Samples	1: 10	1: 10	EA

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Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **MONITORING YEAR 0-5**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Rinse Blanks (per Round)	1	0	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

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Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Low	n/a
Document Review		Yes	n/a
Interviews		No	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		No	n/a
Rebound Study		No	n/a
Start Date		June-2015	n/a
No. Reviews		6	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		No	n/a
Monitoring Systems Inspection		No	n/a
Treatment Systems Inspection		No	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a

This report for official U.S. Government use only.

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
Report			
Required Parameters			
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a

Comments:

This report for official U.S. Government use only.

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **ENVIRONMENTAL COVENANT**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Rename Model		ENVIRONMENTAL COVENANT	n/a
Planning Documents		No	n/a
Implementation		No	n/a
Monitoring & Enforcement		Yes	n/a
Monitoring & Enforcement: Start Date		2010	n/a
Modification/Termination		No	n/a
Type of Site		Former Government Site	n/a
Monitoring & Enforcement			
Required Parameters			
Duration of Monitoring/Enforcement		30	Years
Notice Letters		No	n/a
Guard Service/Security		No	n/a
Reports & Certifications		No	n/a
Site Visits/Inspections		Yes	n/a
Site Visits/Inspections: Number		1	EA
Site Visits/Inspections: Safety Level		D	n/a
Site Visits/Inspections: Duration		1	Days
Site Visits/Inspections: Number of People		1	EA
Site Visits/Inspections: Frequency		Annually	n/a
Site Visits/Inspections: Airfare		0	$ Per Ticket
Site Visits/Inspections: Mileage		0	MI

Comments:

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Estimate Documentation Report

Technology Name: **User Defined Estimate (# 1)**
User Name: **FINAL ROUND OF INJECTIONS**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		FINAL ROUND OF INJECTIONS	n/a
WBS Type		HTRW	n/a
Selected WBS		342.11.04	n/a
Safety Level		D	n/a

Comments: This estimate accounts for the injection of EEO into 32 vertical wells and 10 horizontal wells.

This report for official U.S. Government use only.

Estimate Documentation Report

Technology Name: **Monitoring (# 2)**
User Name: **MONITORING YEAR 6-30**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		MONITORING YEAR 6-30	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		25	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		60	FT
Samples per Event (First Year)		25	n/a
Samples per Event (Out Years)		25	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		1	n/a
Number of Years (Out Years)		25	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	System Water - VOCs	n/a
Secondary Analytical Template	None	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 0	EA
Field Duplicate Samples	1: 10	1: 10	EA

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Estimate Documentation Report

Technology Name: **Monitoring (# 2)**
User Name: **MONITORING YEAR 6-30**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Rinse Blanks (per Round)	1	0	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Abbreviated	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Deep Lariat Gulch Wells	n/a
Number of Wells		10	EA
Well Depth		500	FT
Well Diameter		4	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Unconsolidated	n/a

Comments:

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Estimate Documentation Report

Technology Name: **Well Abandonment (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Horizontal Wells	n/a
Number of Wells		10	EA
Well Depth		500	FT
Well Diameter		4	IN
Well Abandonment Method		Abandon In-Place	n/a
Formation Type		Unconsolidated	n/a

Comments:

Technology Name: **Well Abandonment (# 3)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Remaining Wells	n/a
Number of Wells		350	EA
Well Depth		70	FT
Well Diameter		4	IN
Well Abandonment Method		Abandon In-Place	n/a
Formation Type		Unconsolidated	n/a

Comments:

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Appendix D
Transcript of Public Meeting Regarding Proposed Plan

Former AFP PJKS Proposed Plan Public Meeting

February 8, 2012

MEETING LOCATION:

Wednesday, February 8, 2012
The Peak Foothills Park and Recreation District
6612 S. Ward Street
Littleton, Colorado

REPORTER:
Valorie S. Mueller, RPR
VSM Reporting, LLC
P.O. Box 271208
Littleton, CO 80127
(303) 979-0959

(Meeting began at 7:04 p.m.)

MS. CHARLES: Judy Charles with the Air Force. And we'll get started with our public meeting now.

As I explained before, we'll have about a 15-minute poster session where we'll have the regulators and Air Force personnel and Shaw back there. If you have any questions about what you see, feel free to ask it.

And then I'll call you back up here, and we'll have the briefing session since we have some new people. If you don't want to stay -- the RABs, if you've heard enough, you're excused anytime you want. So you can make your comment or mail it in in writing by February 25th.

So let the poster session begin.

(Recess taken from 7:04 p.m. to 7:17 p.m.)

MR. LAM: Good evening and thank you for being here tonight with us for the Former Air Force Plant PJKS proposed plan public meeting.

My name is Corey Lam. And I'm the Air Force Project Manager for the environmental restoration of the Former Plant PJKS. And I have been involved in this cleanup program at PJKS for the past ten years.

The Air Force has been working closely with the U.S. EPA and the State Health Department to identify Solid Waste Management Units, investigate them, and implement remedies where feasible to protect the human health and the environment.

Removal actions were conducted for the soil Solid Waste Management Units. Interim Corrective Measures have been implemented at the groundwater source areas to address the groundwater contamination.

As you can see, a court reporter is recording everything stated during the meeting. All comments will be part of the official record and addressed in the Responsiveness Summary, which is a report written by the U.S. EPA and the State Health Department.

The meeting will be carried out in two parts. The first one will be, we'll present the information on the selected alternative for the proposed plan and the path forward. And Tom Cooper from Shaw Environmental and David Walker from Colorado Department of Public Health will present the briefings.

And the second part is your opportunity to comment on the proposed plan. So now I'm going to

turn it over to Tom for your briefing.

MR. COOPER: For those of you who weren't here an hour ago, we'll go through this again. Again, as Corey said, I'm Tom Cooper. I'm with Shaw. Shaw has been supporting the Air Force at Plant PJKS now for 12 or 13 years.

So tonight's topic, as Corey said, is the proposed plan. We've basically been through the process of investigation and evaluation and whatnot. And the next step in the process here is to talk about what the proposal is for the final remedy at this point.

So just a little bit of background here. PJKS is 460 acres, approximately, located within what is now the Lockheed Martin facility. It's located to the southwest of Denver. It's about 20 miles from here.

PJKS was originally built in 1957 to support the Titan Rocket Program. And PJKS was what's known as a Government-Owned Contractor-Operated facility, meaning the Air Force owned the facility, but the contractor, Lockheed Martin, and its predecessor companies, were the operators of the facility.

Obviously, there's been -- I think

starting about the mid-'80s is when the investigation started. But in a nutshell, groundwater and soil contamination at PJKS was discovered, and it was related to essentially the rocket testing and fuel development programs that were going on out there.

The primary contaminants in the groundwater are trichloroethene or TCE. It's a common industrial solvent. It was used for a variety of purposes as it is in dry cleaners and things like that.

There's a whole family of chemicals that we refer to as daughter products, cis-1,2-dichloroethylene, or DCE, and some varieties of those. These are essentially breakdown products of the TCE. They weren't chemicals that were used by themselves. They're essentially a breakdown of the TCE. And, of course, vinyl chloride is one of those also.

The other primary contaminant of concern is nitrosodimethylamine. And this is a breakdown product of the hydrazine rocket fuel that was used in the Titan Rocket programs.

Soil contamination, it was primarily polychlorinated biphenyls and poly-aromatic

hydrocarbons, or PCBs and PAHs.

This is essentially the regulatory roadmap. Because of the -- I don't know if convoluted is the right word, but because of the history at PJKS, starting with EPA and moving to the Colorado Health Department, et cetera, the cleanup process has essentially been working parallel under the CERCLA and the RCRA programs.

And essentially this is just sort of showing the analogous terms and the steps along the way. We're essentially about right here in the process, meaning that the investigation phases have been done. The evaluation of what are the options to address the contamination have been done.

The feasibility study report has actually been submitted and was approved not too terribly long ago. So really we're kind of at this point right here where the remedy that's proposed and the feasibility study is being presented to the public through the proposed plan and an opportunity for the public to comment on that. And then those comments will be compiled, addressed, and included into the ROD. The Responsiveness Summary will be part of the ROD.

And then for those of you who have been to

some of these or whatnot, primarily the implementation of the final remedy has really already happened. It's been installed as a series of interim measures, the in-situ bioremediation. So I'll get into a little more detail later.

But some of these steps here that at some sites are after the ROD have really already happened. And then, of course, there's going to be the O&M and long-term monitoring phase.

Primarily what we're here to talk about tonight is the proposed plan, which is essentially a summary of the Focused Feasibility Study, where again, we're looking at the possible alternatives for how to address.

And, again, primarily this document focused on groundwater. The soil sites had essentially been addressed previously through a variety of corrective measures or Interim Corrective Measures. And so if you do review this document, you'll see it's primarily looking at groundwater alternatives. And the soil sites are basically in there just to kind of make the document administratively complete.

So, again, this is kind of what we've been through before, the proposed plan.

Again, the primary function of tonight's meeting is to present the proposed plan. The RAB members have had it, I assume, distributed to you. And then the public comment period goes through February 25th. So you have an opportunity to either make comments tonight after the presentations, or they can be submitted in writing. And I think Gregg will go through all the various options on how to submit comments.

Again, real brief, when the State of Colorado took over as the lead agency in 1998, the site was divided into 56 Solid Waste Management Units. Three of those were groundwater Solid Waste Management Units, and 53 of them were soil SWMUs.

The three groundwater SWMUs are essentially -- we're in the feasibility study. We're about ready to get the remedy selected. But I'll show a figure here in a little bit. It essentially encompassed seven source areas.

And Interim Corrective Measures for TCE have been installed in all seven source areas. They're currently active and are being addressed. It took some negotiations between Lockheed Martin, who is the current property owner now, and the Air Force to work out some of the details because an

environmental covenant is a required piece of this remedy. And Dave Walker from the Health Department -- oh, there he is back there -- is going to talk a little bit more about the environmental covenant piece.

And, again, the Focused Feasibility Study was approved, and it does include a Technical Impracticability Waiver for the NDMA contamination in the bedrock aquifer.

What we call a TI Waiver is one of the waivers that's outlined in CERCLA, and it essentially waives the requirement to meet a specific standard. In this case, it's the State Groundwater Standard for NDMA.

And then, as I said before, the 53 soil sites have been previously closed, some to residential, some to industrial. And the feasibility study essentially has a list of all of the sites and how their closures were achieved.

This is just a cartoon figure of the groundwater contamination. The lighter blue areas are essentially the seven different source areas for the bedrock contamination, all of which feed into one of three of the alluvial drainages at PJKS. This is Lariat Gulch, East Fork Brush Creek, and

West Fork Brush Creek.

This is just a summary figure of the soil sites. I mentioned that some of the soil sites were closed to residential, some to industrial. There were actually three of the SWMUs had very limited areas where the industrial standard was not achieved. When we went through the Interim Corrective Measures evaluation, the capping alternative was evaluated; i.e., instead of removing the soil, you can actually put an asphalt or a concrete cap over it.

Some of these sites were essentially already underneath parking lots, so the remedy that was selected for those was to simply maintain those asphalt or concrete parking lot areas as an official cap to the contamination.

This is just little bit about the feasibility study, what it includes. In our case, as I mentioned, Interim Corrective Measures for the PCB contamination have already been installed, in-situ bioremediation. So rather than compare a large number of alternatives when we already knew the in-situ bioremediation was working, we did a Focused Feasibility Study. We just basically evaluated that remedy, plus no action.

The feasibility study also has to go through the rule books and determine what all regulations need to be met. We call them applicable or relevant appropriate requirements or regulations.

So in addition to looking at various remedial alternatives, you also have to come up with a list of what all the rules you have to meet.

Remedial action objectives, that includes things like points of compliance; you know, where you have to be in compliance with the various standards and whatnot. And, again, the feasibility study does include the Technical Impracticability Waiver. That was actually included as a section to this document.

And as I said, this is applicable only to NDMA in the bedrock source areas, and the waiver essentially waives having to meet the Colorado basic standard for that. But it doesn't waive having to protect human health and the environment. And that's where the environmental covenant piece comes into the final remedy.

So just a bit of a description of what's in the document. The take-home message is that the preferred alternative that's being proposed is in-situ bioremediation with the environmental

covenants.

This is just a figure that shows a Technical Impracticability Waiver has to apply to a specific place in space. And this is essentially just a figure. It shows the historical bedrock NDMA contamination. Many, many years of data indicate these plumes are stable. They're not moving. They're not migrating. They're not changing in concentration. So the hatched area that goes around them is actually the area that the TI Waiver actually applies to.

So really, as I said, the focus at tonight's meeting is to essentially get the proposed alternative out to the public, an opportunity to make comments. And, again, Gregg will talk about that mechanism. Obviously, comments can be submitted up to the end of the period of February 25th.

And then once those comments are all compiled, addressed, they'll be included in the final document, the Record of Decision. And, again, that's the document that both the Air Force and the regulatory agencies will sign that sets forth the requirements of what has to be done.

And then since there will be contamination

remaining in place in the groundwater and obviously the soil above unrestricted use, the site will be subject to five-year reviews. And that's every five years moving forward. It's a formal evaluation to make sure that the remedy remains protected and nothing's changed that says you have got to do something different.

And, again, that will be ongoing as long as there is contamination above unrestricted use.

Questions? If not, we'll --

MR. PEREZ: This is Ernesto Perez, and I have a couple of questions.

On your proposed plan, you talked about the alternative 2, which is that's where you're proposing, is already implemented. Can you tell me, do we need additional injections, or have all the injections already been done?

MR. COOPER: Currently, there's a contract in place to do additional injections.

MR. PEREZ: I understand. Okay. Further than those, do we need more?

MR. COOPER: That's part of what will be discussed in the post-ROD. There's going to be an O&M plan that's developed. So the length of how long the injections will need to continue has not been fully

determined yet. It's going to be essentially based on the data, so to speak.

MR. PEREZ: So you believe there should be additional -- this is Ernesto Perez. Do you believe there's going to be additional injections needed or not?

MR. COOPER: If you're asking me --

MR. PEREZ: Right.

MR. COOPER: -- that's a discussion between the Air Force and the regulatory agencies. It's going to be data-driven, so --

MR. WALKER: This is Dave Walker from the State Health Department. Tom is right. The number of injections that are going to be required after this initial round is done is still under negotiation.

What we've talked about in the past is that we will do at least one rebound study to see how things are going. And everybody anticipates that there will be a need for at least one more injection round after that and then another rebound study. So there will be a minimum of one more injection and possibly two or more.

The objective is not to reach state groundwater standards for TCE in the bedrock source areas. If it happens, that's wonderful. But it

doesn't have to happen. The objective -- the remedial action objective that's discussed in the feasibility study report is take down the concentrations of TCE in the bedrock groundwater to the point where they no longer cause groundwater contamination in the alluvial beyond the PJKS boundary.

It's a pretty complex remedial action objective. And it requires discussion of transport, transport times, and not all of that data is available yet.

MR. EVANS: This is Roy Evans. How many more injections are under your current contract?

MR. COOPER: Essentially one more round for all of the wells that are in the program. One more injection in each of the wells.

MR. EVANS: Okay.

MR. WALKER: Thank you, Tom. Again, my name is Dave Walker from the State of Colorado Health Department. I'm the project manager for the Air Force Plant PJKS cleanup.

I work closely with David Rathke from the U.S. Environmental Protection Agency. I am responsible for RCRA corrective action, or hazardous waste corrective action, and Dave is responsible for

making sure that all of the CERCLA requirements are taken care of since this is a National Priorities List site.

The actives go hand in hand. The mechanism -- the enforceable mechanism that we use, which is called a consent order, requires the State Health Department to make sure that during the hazardous waste corrective action activities that all of the CERCLA activities or all of the information necessary to meet CERCLA requirements is also collected.

So far it's worked very well. As a matter of fact, that's part of the reason we are using CERCLA terminology here because this whole ROD process requires all of this public input officially.

As Tom talked about, the PJKS final remedy relies heavily on institutional controls, either -- making sure that the property is only used in the future for industrial. There's areas or portions of the property that have not been cleaned up for residential use.

In addition, you've seen that a lot of the groundwater remains contaminated at the site. So there will be an institutional control to require no

use or no potable use of the groundwater at the site.

Basically, in order to get there, the engineering controls and land use controls, we are relying on something that the State of Colorado legislature passed in 2001.

Everybody loves to rely on institutional controls and engineering controls for final remedies. But prior to 2001, the State Health Department were pretty much forced to clean up to unrestricted use no matter whether that made sense or not because we had no way of making sure that those institutional controls or engineering controls were maintained in the future. The legislature gave us that with the environmental covenant.

We have -- at the time, it was statutory authority. That means written into the Colorado law. And now we also have regulatory authority to enforce against a landowner who has signed up for these restrictions, to make sure that they follow what they're supposed to do.

The key for an environmental covenant is it's not only binding against the property owner who created the restrictions; it's binding against all future property owners. So it doesn't matter. You

can't come in and say, Well, I didn't know about the restriction. It doesn't matter. It's still binding.

To help people make sure that they don't buy a piece of property without knowing about the restrictions, it's recorded in the deed for the property and runs with the property. So anybody doing their due diligence should be able to find the restrictions.

As most of you know -- there's a lot of environmental professionals here -- the goal of everybody's cleanup is to get to unrestricted use. Clean up to residential standards, clean the groundwater to state groundwater standards. It helps the property owner, limits future liability. Everybody is happy.

But we all know, especially in these times, and for small properties, that money is not growing on trees. And cleanup to unrestricted use is very rarely economically possible. It's technically not possible if, for example, you have a building where the contamination of the soil has extended below the building and somebody is actively using the building.

You can't destroy the building to get rid

of the contamination, but it can still cause a potential. As long as the building covers the contamination, it's no big deal. But you have to put restrictions into place to make sure that nobody is going to dig a hole in that basement to put a utility in and wind up being exposed to contamination.

Therefore, you put an environmental covenant restriction on digging on the property, and that runs with the land as long as people know how to safely handle that dirt.

So basically we're eliminating the threat to human health by breaking the chain. If a person can't touch the contamination or breathe it or eat it, then it's safe. And if as long as an industrial property is cleaned up to industrial use, you don't wind up with a day-care center on there, then it's also safe.

The other thing that the legislature really helped us with is that any CERCLA cleanup or RCRA corrective action cleanup has to have an environmental covenant if you don't clean up to unrestricted use. It's not an option. The facility or the property owner has to agree to the covenant.

And we don't grant environmental covenants

just in collusion with the property owner alone. We also make sure that the local -- excuse me -- the city or county level government and planners know what's going on here so that we don't tell a property owner, yeah, you can restrict that to industrial when the city planned to have a mixed use residential there. That wouldn't make anybody very happy.

We also check -- force the property owner or sometimes we do it to check with people who have right-of-ways or any type of easement on the property. For example, the water department might have their huge water line or a gas main running through there. If you put a restriction on digging on the property and tell people they can't dig there, well, how are they going to fix their water line? So they also have to be notified of the restriction.

The key part of an environmental covenant is everybody loves them when they're first signed. The owner doesn't have to spend as much money doing the cleanup. Everybody is happy. "Yeah, I don't mind that restriction." But then when I retire or somebody -- the project manager goes away or the property gets sold, it gets forgotten.

Well, we have a mechanism in place now. It's our database that we have at the Health Department. It keeps track of the covenants. We charge $1,000 a year. There's typically a self-reporting requirement with the covenant.

So every year, the owner has to certify that, yes, we're complying with the requirements of the covenant. And then we also do inspections of the property on a, like, one-year or up to five-year basis.

And we're not the only ones who care about whether the covenant gets managed or not. The owner of the property has liability if somebody goes in and starts doing something they're not supposed to. So it's in the owner's best interest to make sure the covenant is taken care of.

And then, of course, the local government. They're, most times, our best ally when it comes to environmental covenants because they notify us if somebody comes in and wants to change the land use, they have a building permit and they want to put up a new building, they want to dig, et cetera.

So that's how we keep track of the covenants and hopefully keep track of the restrictions.

The state environmental covenant law is its own law. It has its own enforcement capabilities. At PJKS, we also happen to have a consent order to require cleanup and will have a consent order to require post-closure care. But this law by itself has enough authority to allow us to seek administrative penalties and administratively get people to comply with the covenant. And if not, we go to the courts and seek an injunction. If they ignore the courts, they do it at their own risk. And that opens them up to other problems.

The property owner can also -- if somebody violates their covenant, the property owner can sue that person, because, again, it's their liability, not the state's.

For the Air Force Plant PJKS, we are going to have the environmental covenant. The property is owned by Lockheed Martin who will eventually have to sign the covenant. But the work to develop the covenant and negotiate the conditions is all being done by the Air Force. And then Lockheed, as the owner, obviously has to agree with the conditions.

PJKS -- again, to make it simple, the entire property is being limited to industrial use

only. As you'll see in a second and what Tom said, I would say 75 percent of the property is clean to unrestricted use. But it's much simpler to just say, restrict the whole thing to industrial, because right now that meets with Lockheed's future use.

That can change in the future. People are allowed to change environmental covenants. In order to do that, you have to eliminate the reason that the covenant was there in the first place.

If the soil was contaminated, you have to clean up the soil to an unrestricted use. If the groundwater was contaminated, you have to clean up the groundwater to state groundwater status.

PJKS, the entire property, again, most of the groundwater is not contaminated. But we will have a prohibition on the entire property for use of potable water. It doesn't really matter because nobody is using the water anyway. So that's really not hurting anybody.

And then with the asphalt covers that Tom was referring to on some of the smaller areas at the site, those have an annual inspection requirement and maintenance as needed. And that's kept -- we do a semiannually -- excuse me -- biennial inspection at the facility anyway. So we check those every

time we go out -- check their records.

Again, one of the things that -- it makes it sound like the whole PJKS site is contaminated and blah-blah-blah and we didn't do any cleanup. But in reality, of 53 of the Solid Waste Management Units, 37 are clean closed, the soil units. That's pretty good. And that doesn't include all of the surrounding areas that were never investigated because they already met residential unrestricted use standards.

12 SWMUs require the safe for industrial use but not safe for residential. And then, as I was telling some of the folks in the crew, there is one post-closure hazardous waste unit on the property. The T8A Impoundment was a real hazardous wasteland-based unit, and it is currently under post-closure care.

Eventually, that will probably be wound up into the environmental covenant because realistically the only requirement is to make sure that nobody went in and dug up the concrete, nobody is in there trying to eat the concrete, or Lockheed is not trying to turn it into a skate park, which is what my idea is for it. They don't like that idea, by the way. Something about liability.

And then, again, the three areas where they're currently covered with an asphalt cap, again, there's an annual inspection requirement to make sure, and fix the cap if it's broken.

So, again, this slide was more for the RAB. But the soil covers -- the covers on the PCB-contaminated soil were actually done as an Interim Measure. All of the soil units at the site were addressed -- the remediation of them, including digging up a lot of PCB-contaminated soil, were done as interim measures to get them completed and off the books before we got to the Record of Decision stage.

The RAB members were briefed on this, and they did go through their own public comment period, as far as being an adequate remedy for those sites.

PCBs are the only thing we're worried about. To be quite honest with you, we don't know the source of most of the PCBs. They were just there. It's only a problem if you eat the dirt, breathe in the dirt, or go play in it.

So the pathway for humans to be impacted by PCBs is cut off by the asphalt covers. And as long as you maintain them and that that contamination can't run off due to precipitation

events, the thing is protected -- the remedy is protected.

Again, into the future, the environmental covenant, which hasn't been signed yet -- that will be signed very soon after the ROD is signed -- will require the covenants to be maintained; inspections; and then, of course, no future residential use of the property and no use of the groundwater.

That's it. So understand the environmental covenants are one of the most important parts of this remedy.

Any questions? All right. Thank you.

MR. MCGRAW: My name is Gregg McGraw. I'm with Shaw Environmental, and we've reached the public comment portion of this meeting tonight.

I've got some prepared information, but before I go through it, I thought it might be a good idea to ask if anybody here intends to or even is thinking about making a statement this evening. Anybody?

All right. There are two ways you can make comments on this project -- on the proposed plan. The comment period runs through February 25th. You may submit comments in writing. Either mail them or send them by e-mail. Comments

mailed that are postmarked the 25th of February will be accepted. After that, sorry. Once the comment period closes, they can't accept it. It's a 45-day period under the RCRA regulations.

If you wish to make a verbal comment tonight, you may do so. We haven't received any speaker registration cards, and it's the Air Force's estimation that no one is really going to make a comment tonight. So that's why I asked if anybody has an inkling to do this. Should we continue this? Otherwise, we're going to adjourn the meeting.

RAB members? No? Okay.

There are comment forms on the table. They're pre-addressed. You just stick a stamp on them and send them in to us. The fax sheets have e-mail addresses, as well as addresses that you may write -- that you can write to on there, and you can send those in.

And I believe, ladies and gentlemen, that that concludes tonight's presentations and tonight's meeting. We thank you very much for your attendance. The meeting is over.

(Meeting concluded at 7:49 p.m.)

CERTIFICATE

STATE OF COLORADO)
) ss.
COUNTY OF JEFFERSON)

I, VALORIE S. MUELLER, Registered Professional Reporter and Notary Public in and for the State of Colorado, duly appointed to report the herein meeting, certify that the meeting was taken in shorthand by me at the time and place aforesaid and was thereafter reduced to typewritten form by me and processed under my supervision, the same consisting of 27 pages, and that the same is a full, true and complete transcription of my shorthand notes. I further certify that I am not related to, employed by, or counsel to any of the parties herein, or otherwise interested in the events of the within cause.

IN WITNESS WHEREOF, I have affixed my signature this 16th day of February, 2012.

My Commission Expires: December 10, 2015.

_____
VALORIE S. MUELLER
Registered Professional Reporter