FIVE-YEAR REVIEW REPORT

KENNECOTT NORTH ZONE SUPERFUND SITE

APPENDIX J: BACKGROUND/REMEDIAL ACTIONS

1. BACKGROUND

1.1. Kennecott Sites

The Kennecott Sites (Sites), Kennecott North Zone and Kennecott South Zone, were divided into 24 operable units (OUs). Later, one OU was deleted because it was not owned by Kennecott and, after characterization, was addressed as separate site. The following table summarizes the five-year review history for the Sites.

Table 3-1 Kennecott Sites and Five-Year Review History

South Zone	**OUs**	**Status**
Butterfield Creek	3,6,7, 17, 18	Sept. 2009
Bingham Creek	1, 4, 5,10,11,	June 2010
SW Jordan Valley groundwater plumes	2, 12, 16	No Review
North Zones	**OUs**	**Status**
Operational areas, Canyons, Wetlands, Groundwater, GSL and Shoreline	8, 9, 13, 14, 15, 18, 19, 22, 23,	First Review – this document

The Kennecott North Zone is an industrial area at the north end of the Oquirrh Mountains and at the south shore of Great Salt Lake, west of Salt Lake City, Utah. The site is next to the community of Magna. Since 1906 the Kennecott North Zone has been used to process copper, lead, zinc, molybdenum, arsenic, gold, and silver-bearing ores. The wastes produced contain hazardous substances, including heavy metals. Sludge and soils were/are contaminated, as were/are surface and groundwater that affect wetlands located between the smelting and refining operations and the south shoreline of the Great Salt Lake.

The Kennecott South Zone consist of industrial and open space/buffer areas near or in Bingham Canyon, Salt Lake County, Butterfield Canyon, Salt Lake County, and in Pine Canyon, Tooele County. Since mining began in the late 1800s at what is now the Bingham Canyon pit mine, soils and water have overtime contained concentrations of metals exceeding unrestricted land use standards. Such resulted from operations addressing the mining, milling, laundering, transporting of ore and mining influenced water. Water management practices over time added to the potential introduction of heavy metals to the areas.

Transitional areas, connecting the mining and milling operations on the South Zone to the smelting and refining (and waste management) operations on the North Zone, consist of the footprints for pipelines and both historic and current rail corridors. Pipeline corridors have had spills in the past causing for the release of large volumes of slurry with low concentrations of heavy metals. Rail corridors were constructed using slag for ballast and waste rock for earthen trestles. Both slag and waste rock will contain concentrations of heavy metals above unrestricted standards. The rail corridors can also have ore deposits, and other operational wastes located adjacent to the corridors.

Today, Kennecott maintains active mining operations on or near all of the operable units. Portions of the Sites are adjacent to residential communities and one Operable Unit (OU9,

Magna) is a residential community. In addition, visitors continue to enjoy the recreational opportunities offered by the Great Salt Lake which is part of OU22.

Kennecott North Zone includes eight OUs (which are part of this report):

- OU8 Waste Water Treatment Plant and Sludge Ponds
- OU9 Magna Soils
- OU13 Smelter and Acid Plants
- OU14 Refinery
- OU15 Mills and Tailings Pond
- OU19 Smelter Fallout
- OU22 Great Salt Lake, Shoreline Wetlands
- OU23 North End Groundwater

Each OU has its own unique history, physical characteristics, environmental problems, and initial response actions which will be discussed in subsections 1.2 to 1.8 that follow.

Future Land Use

OUs in the North Zone are likely to remain designated for industrial land use in the foreseeable future, with two exceptions: OU9 and OU19. OU9 will remain residential; OU19 is likely to remain in use as open space and buffer.

Risk Assessment and Conclusions

Risk to human health: An EPA contractor conducted the assessment and produced preliminary remediation goals, as detailed in the document entitled *Final Preliminary Remediation Goals for Addressing Risks to Human Health from Exposure to Chemicals in Kennecott Soils* (December 30, 1999). A risk assessment task force composed of toxicologists and health professionals from the EPA, UDEQ, UDOH, SLVHD and stakeholders from the communities and Kennecott aided in the evaluation of the assumptions used in the risk assessment.

Risks applicable to all OUs in the Sites are summarized here:

- Monitored potential contaminants: Although arsenic, cadmium, chromium, copper, molybdenum, lead, selenium and zinc were monitored at the site, only lead and arsenic were found at concentrations of a human health concern for industrial sites. Therefore, lead and arsenic were the principal contaminants of concern (COC). An exception to this was OU9, where arsenic, lead, and copper were suspected to pose a potential risk and were named as the principal COC.

  Selenium is monitored as it pertains to ecological risk reasons as part of the remedy selected for OU22. Groundwater concerns from arsenic and selenium are addressed in the subsection for OU23.

- Hazardous metals: An evaluation of arsenic, lead and other hazardous metals (including cadmium, copper, and selenium) in soil and the development of clean-up levels was made with the intent of being protective of workers while they are on break, either eating lunch or taking a hike on the grounds outside of the normal work areas, and visitors with limited access. Non-cancer exposure scenarios were developed to provide information in the evaluation of protecting human health.

The EPA used its methodology to assess risks associated with non-residential adult exposure to lead in soil, i.e. EPA adult lead algorithms. The algorithms were used to develop preliminary remediation goals for adults exposed to metals on an intermittent basis.

The risk assessment task force considered the following site specific parameters to help make risk management decisions for the cleanup values:

- Because the forms of metals were suspected to vary in chemical form from OU to OU and from pile to pile (depending upon the waste), the EPA used 100% relative bioavailability (relative to the soluble form).
- Exposure frequency and duration, as noted in Tables 1.2, 1.3, 1.4 of the September 2002 ROD (ROD).
- Soil and dust ingestion and inhalation rate assumptions, as noted in Tables 1.5 and 1.6 of the ROD.
- Since the EPA adult lead model could not accommodate the episodic exposures typical of non-residential land use, the exposure frequencies were assumed to be one day/week throughout the year.

- Carcinogen evaluation: Metals that have the potential to increase cancer incidence in the potential receptors were also evaluated. This evaluation was developed using the site specific parameters listed above under the discussion of metals, plus using the EPA cancer risk Central Tendency Exposure calculations with the mid-range cancer probability at 10^{-5} (or 1 in 100,000).

The preliminary remediation goals were summarized in the 2002 ROD and are replicated here in Table 3-1. This table also summarizes the removal action levels specified in the EPA's Administrative Order on Consent, CERCAL-VIII-95-04, (June 1996 AOC). These levels were based on standard default values for soil ingestion at industrial sites and were used during the early response work prior to the ROD.

Table 3-2 Summary of Preliminary Remediation Goals For Land Uses (mg/kg in soil, unless otherwise noted)

Land Use	As	Cd	Cr	Cu	Mo	Pb	Se	Zn
Industrial/Commercial	261	2,764	8,381	10.3%	13,972	4,414	13,972	83%
Agricultural	100	2,148	6,444	79,689	10,740	8,500	10,740	64%
Recreational (ATV)	283	758	114	25.2%	34,067	2,207	34,067	pure
North Zone Removal Action Level	200	1,000				2,000	1,000	

The EPA selected unrestricted land use standards for arsenic and lead based upon default assumptions used in the EPA Adult Lead algorithm and best professional judgment (based upon realistic risk management practices) as it pertains to arsenic. These two unrestricted land use standards (arsenic – 50 mg/kg and lead – 500 mg/kg in soil) are included in Table 1.8 of the 2002 ROD.

- The ROD concluded that for most of the contaminants of concern, the removal action levels were sufficient to protect human health in OU8, OU13, OU14, and OU15.
- The ROD does not give an opinion about detected arsenic and lead concentrations in OU9 Magna Soils. Arsenic and lead concentrations were found to exceed the standard for unrestricted land use (in a few locations) after review of the 1990 UDOH and 1994 BOR studies.
- The ROD did not specify that human health risks existed in OU19. However, upon further comparison sampled locations demonstrate concentrations of both arsenic and lead that exceed the unrestricted land use standard.

Ecological Risk: The EPA, UDEQ, and Kennecott performed ecological risk assessments for the sites at the time the ROD was prepared. A Biological Technical Advisory Group (BTAG) was formed to advise the EPA with regard to the sensitive habitats and risks. In a manor analogous to the human risk assessment, the sites were divided into different habitats present and each habitat was studied separately. The habitats included upland, riparian, south shore wetlands, and the Great Salt Lake.

- The ROD did not specify ecological risk existed from the existence of elevated concentrations of the contaminants of concern at OU8, OU9, OU13, and OU14.
- The ROD specified that ecological risk could exist at OU15, as it pertains to selenium and the avian receptors in surrounding wetland habitats.
- The ROD specified that ecological risk could exist at OU19, as it pertains to the consumption of plants with a capacity to uptake and concentrate selenium. Details are provided in the subsection 3.7 OU19 Smelter Fallout.

Ecological risks due to elevated selenium in soils/sediments migrating from the OUs are addressed under OU22. Groundwater with elevated concentrations of selenium that reaches the surface in surrounding wetlands and poses a threat to the avian receptors in OU22 are addressed under OU23.

The ROD does note that within the North Zone there is a generalized risk to terrestrial herbivorous receptors if plants with a capacity to uptake and concentrate selenium are used for revegetation efforts. This risk is predominantly associated with the drainages and ridgeline of the Oquirrh Mountains, explained under OU19.

1.2. OU8 Waste Water Treatment Plant and Sludge Ponds

Location, Setting and History

OU8 consists of the former Waste Water Treatment Plant (WWTP) and Sludge Ponds, which were constructed by Kennecott to treat industrial effluent from the Smelter (OU13), the Refinery (OU14), and Magna Mill (OU15). The sludge produced by the plant was slurried to nearby ponds (i.e. sludge ponds) for disposal. Treated water was delivered to the Magna Tailings facility from whence it was recycled for use in processing at the mills (OU15) or discharged to the C-7 ditch and eventually into the Great Salt Lake (OU22). OU8 is located just to the west of the Magna Tailings facility (OU15) and down gradient (to the north) of the Kennecott Refinery (OU14).

Facilities at OU8 include: the WWTP, the soils located underneath the WWTP, Sludge Pond A, Pond B, Pond C, Pond C+, and Pond D. For an understanding of the history, location and setting for each of the listed facilities please refer to *Oquirrh Mountains Mining and the Environment* by Dr. Eva J. Hoffman (April 21, 2005).

Extent of Contamination

Table 1-A in Appendix E summarizes the pre-removal maximum and mean concentrations of arsenic, lead and selenium at the WWTP and sludge ponds.

1.3. OU9 Magna Soils

Location, Setting and History

OU9 consists of the soils in the town of Magna, Utah.

For an understanding of the history, location and setting for each of the listed facilities please refer to *Oquirrh Mountains Mining and the Environment* by Dr. Eva J. Hoffman (April 21, 2005).

Extent of Contamination

Four separate sampling events took place in Magna, each with a different objective.

- In 1990, the UDOH conducted a PA/SI sampling for the Kennecott Tailings site with an objective to determine if metals in soils were above background concentrations. Forty-two samples were collected from thirteen locations.
- A second sampling event occurred in 1994 as part of a removal assessment by EPA. The objective was to determine if emergency response action was needed in Magna. The September 2002 ROD notes that two-hundred and fifty-four surface samples (zero to four inches) were collected with emphasis on the northwest part of town (older section) and adjacent to Tailings Impoundment. The results of the first study determined that the majority of the arsenic and lead concentrations were below the Sites' unrestricted land use standards for arsenic and lead. Two samples were above the arsenic unrestricted land use standard (respectively 58.5 mg/kg and 186 mg/kg); both results were qualified as estimated. The results of the second study determined that the majority of the arsenic and lead concentrations were below the Sites' unrestricted land use standards for arsenic and lead. One sample was determined to have an arsenic concentration of 58 mg/kg, and two samples were determined to have lead concentrations of 500 mg/kg and 540 mg/kg. The results of the second study are discussed further under Section 4.2 in further detail. All results noted in the paragraph were derived from laboratory analysis, not XRF analysis.
- The third and fourth sampling events were actually a study of the uptake of lead and arsenic into garden vegetables. The vegetable uptake studies' first phase focused on the collection of soils from as many gardens in Magna which could be found and accessed. Phase I included samples from 37 gardens, Phase II included 45 soil samples were collected from 14 of the previously sampled gardens. The garden vegetable study indicated that the concentrations of arsenic and lead in vegetables were too low to include as a major pathway in exposure calculations for Magna. The bioconcentration was calculated for arsenic and lead for a variety of vegetables. For lead, the carrot bioconcentration factor was 4.6^{-03}, the tomato bioconcentration factor

was 5.9^{-04}, and the zucchini bioconcentration factor was 8.9^{-05}. Based upon these studies EPA determined that no removal action was needed in Magna.

In 1995 Kennecott funded the University of Cincinnati and the Salt Lake County Health Department to conduct a blood lead study of Magna Children. The study was never published and reported exceedances of the blood lead level of 10 µg/dl could not be explained (in terms of where the exposure took place since soil lead levels were low). Later in 1996, the Agency for Toxic Substances and Disease Registry conducted a public health assessment for the Magna area, among other areas. After examination of air quality measurements in Magna, the ATSDR concluded that the air exposure situations pose no apparent public health hazard. After reviewing EPA's soils data, ATSDR concluded that the soils exposure situation pose no apparent public health hazard.

Table 2-A in Appendix E summarizes the characterization maximum and mean concentrations of the arsenic, copper, and lead in soils located in the Town Magna.

1.4. OU13 Smelter and Acid Plants

Location, Setting and History

OU13 consists of the footprints of historic and current smelters and associated facilities. The smelters were/are designed to process concentrates produced by the various mills (OU15 and OU24) operated at the sites. The products produced are copper anodes and sulfuric acid (from the off-gasses in the furnaces). The wastes produced by the smelters included slag, flue dusts, stack gases, fugitive air emissions, and spills of process waters. Historical waste management and spills at OU13 caused impacts to soils underlying facilities at OU13 and down gradient in the Garfield Wetlands (OU22), as well as impacts to the shallow and principal aquifers underlying OU13 (OU23). The groundwater contamination under the smelter facility is addressed under OU23. Elevated concentrations of the COCs in the Garfield Wetlands and the potential for ecological risk are addressed under OU22. Soils at OU13 can exceed the sites' unrestricted and industrial land use standards for the metals of concern. The overall Smelter complex is located just south of State Highway 201, near the western boundary of Salt Lake County at the mouth of Kessler Canyon and incorporates approximately 160 acres.

<u>Areas of concern at OU13 include</u>: the footprints of the historic and current smelters, footprints of historic acid plants, associated infrastructure, material handling and smelter waste areas, and underlying soils. The facilities include: Reverberatory Smelter, Noranda Smelter, Outokumpu Smelter, East Yard, RR Yard Soils, Slag Tailings Pipeline, Section 17 Pump Station, Process Water Pipeline, Weak Acid Pipeline, Weak Acid Lift Station (a.k.a. West Weak Acid Lift Station), Section 21 Reverse Osmosis Plant, Pump Stations, East and West Process Water Ponds, Japanese Springs (1 and 2), Japanese Springs (3 thru 5), Wooden Flume, Acid Plants and Associated Facilities and Footprint Soils, New Acid Plant, Hydrometallurgical Plant, Acid Tank Farm, Praxair Footprint, Thaw Shed, Cherry Bowl, Concentrate Storage Pad, Material Handling Building, Slag Pot Cooling Area , Roundhouse, Slag Crushing Mill, Row 5 Screening Plant, Slag Mill Concentrator Thickener, Standby Fuel Station, Black Rock Tailings Pond, Smelter Slag, Last Chance Pond, Flue Dust Disposal Area, East Stormwater Pond, West Stormwater Pond, Railroad Crossing Spill, Smelter Landfills, Smelter Parking Lot.

For an understanding of the history, location and setting for each of the listed facilities please refer to *Oquirrh Mountains Mining and the Environment* by Dr. Eva J. Hoffman (April 21, 2005).

Extent of Contamination

Table 3-A in Appendix E summarizes the pre-removal maximum and mean concentrations of arsenic, lead and selenium at the Smelter complex.

1.5. OU14 Refinery

Location, Setting and History

OU14 consists of the footprints of historic and current refinery, precious metals plant, associated facilities and waste disposal/storage areas. The Refinery complex comprises facilities which perform the final processing step, refining the copper anodes produced by the smelter, and packages the final products for sale and shipment. The products produced are copper cathodes, gold and silver ingots, platinum, palladium, rhodium and selenium retort. Historically, liquid wastes were originally discharged on site then later to the Wastewater Treatment Plant (OU8). Historical waste management and spills at OU14 caused impacts to soils underlying facilities at OU14, as well as impacts to the shallow and principal aquifers underlying OU14. The groundwater contamination under the refinery facility is addressed under OU23. Elevated concentrations of the COCs in the Garfield Wetlands and the potential for ecological risk are addressed under OU22. Soils at OU14 can exceed the Sites' unrestricted and industrial land use standards for the COCs. The Refinery complex is located just south of State Highway 201, approximately 1.5 miles east of the Smelter complex (OU13), and incorporates approximately 45 acres.

Areas of concern at OU14 include: the footprints of: Old Refinery and Precious Metals Plant, New Refinery and Precious Metals Plant, Electrolyte Purification Building, Lead Shop, Oil Storage, Boiler Building, Assay Lab, Refinery Evaporation Pond (Electrolytic Pond), East Rail Yard Site, Electrolyte Pipeline Corridor, West Laydown Yard, Kessler Spring Dump, R1-R2 Containment Area, Bosh Pond, Santa Fe Basin, Refinery Stormwater Canal, Garfield Townsite.

For an understanding of the history, location and setting for each of the listed facilities please refer to *Oquirrh Mountains Mining and the Environment* by Dr. Eva J. Hoffman (April 21, 2005).

Extent of Contamination

Table 4-A in Appendix E summarizes the pre-removal maximum and mean concentrations of arsenic, lead and selenium at the Refinery complex and associated facilities.

1.6. OU15 Mills and Tailings Pond

Location, Setting and History

Operable Unit 15 (OU15) includes the historic facilities which comprised the first step of the mineral beneficiation process, the grinding of ore and separation of minerals via gravity and flotation processes. OU15 also includes waste areas associated with grinding and concentrating operations, current mill tailings disposal facilities, process water management facilities, conveyance pipelines, and power generating facilities. Two products were/are produced from the milling operations, copper concentrate and tailings (each with varying concentrations of metals). The major facilities included the Bonneville Crushing and Grinding Plant, Magna Concentrating Mill, Arthur Concentrating Mill, associated infrastructure and waste disposal areas. The major waste disposal area (for tailings) included the Magna Tailings Impoundment (South and North Tailings Impoundments). Today the only operating mill, Copperton Concentrator, is part of OU24 which delivers via the Tailings Pipeline tailings to the North Tailings Impoundment and

concentrate via the Concentrate Pipeline to the Smelter (OU13). The mills were all interconnected with each other and the Refinery and Smelter complexes through a series of rail sidings and spurs. The network of rail corridors is part of Kennecott's Northend Operational Rail Services which are part of OU24. Overall, combined the facilities in OU15 are located on the eastern extent of the Northern Oquirrh Mountains.

Areas of concern at OU15 include: the footprints of: Magna Mill (a.k.a. Utah Copper Mill, and North Concentrator), Arthur Mill (a.k.a. Boston Consolidated Mill), Magna Leaching Facility, Lime Kilns, Lime Slacking Plant, Reagent Stills, Iron Foundry, West Debris Site, Railroad Debris Site, Crucible Site, Arthur Second Line Ditch, Bonneville Concentrator (a.k.a. Bonneville Crusher), Bonneville Railroad Scrap Yard, Bonneville Gate Hillside site, Little Valley Settlement Ponds, North Slope Site, Magna Administration and Safety Building, Railroad Slope site, Concentrate Loading Area, East Debris site, Magna Process Water Pond, Diving Board Tailings area, Tailings Slurry Pipeline, Concentrate Slurry Pipeline, Magna Flume, South Tailings Impoundment (Magna Tailings Facility), Arthur Step-back Repository, Tailings Pond Landfill, Ragtown and Snaketown, Historic Roads, Riter, Historic Rail Routes, North Tailings Impoundment (Magna Tailings Impoundment North Expansion), Chevron Fertilizer Plant, Morton Salt Plant, Wetlands Mitigation Areas: Morton Salt Property, Bothwell and Swaner Property, Heughs Creek Associates Property, Blackhawk Pond, North Point Consolidated Canal, Goggin Drain, Utah Copper Power Plant, Kennecott Power Plant, and Power Substation.

For an understanding of the history, location and setting for each of the listed facilities please refer to *Oquirrh Mountains Mining and the Environment* by Dr. Eva J. Hoffman (April 21, 2005).

Extent of Contamination

Table 5-A in Appendix E summarizes the pre-removal maximum and mean concentrations of arsenic, lead and selenium at the Mills, Waste Storage Areas, Wetland Mitigation Areas and Power Plants.

1.7. OU19 Smelter Fallout

Location, Setting and History

OU19 consists of the airshed around the Kennecott North Zone facilities that has historical received emissions from a number of historic facilities (i.e. Magna and Arthur Mills, OU15, Refinery, OU14, and the Reverberatory and Noranda Smelters, OU13 D) with a focus on emissions from the historic smelters. Dependent upon emission control infrastructure, sulfur dioxide emissions from the smelters historically contained various quantities of arsenic, lead and selenium (though mostly arsenic and lead). The height of emission stacks also contributed to the severity of the problems experienced in the airsheds around these facilities. For example, the Reverberatory Smelter had two short stacks located in lower Kessler Canyon which are suspected to have facilitated the distribution of sulfur dioxide emissions that lead to the devegetation of this canyon and the deposition of selenium and arsenic onto the surfaces of this canyon.

Areas of concern in OU19 include: Little Valley Canyon, Kessler Canyon, Black Rock Canyon, Coon Canyon, Harkers Canyon, Pine Canyon (OU20), and the Erda Airshed. For an understanding of the history, location and setting for each of the listed facilities please refer to *Oquirrh Mountains Mining and the Environment* by Dr. Eva J. Hoffman (April 21, 2005).

Soils located in lower Kessler Canyon below the lowest sedimentation dam are part of OU13. Little Valley Canyon incorporates approximately 3,696 acres, Kessler Canyon incorporates 3,883 acres and Black Rock Canyon incorporates 1,434 acres. The Erda Airshed includes the most northern portions of Tooele County, incorporating the communities of Erda, Stansbury Park and Lakepoint. The area of Tooele Valley which was characterized incorporates 18,560 acres.

Extent of Contamination

Table 6-A in Appendix E summarizes the site characterization maximum and mean concentrations of the COCs at the downwind canyons and communities (i.e. arsenic, lead and selenium), as reported in Table 9.5 of the September 2002 ROD.

1.8. OU22 Great Salt Lake, Shoreline Wetlands and OU23 North End Groundwater

Location, Setting and History – OU22

OU22 consists of the Great Salt Lake (GSL), its shoreline and wetlands (i.e. Garfield Wetlands). OU22 is located north of the Smelter (OU13), Refinery (OU14) and north and west of historic milling and mill waste management facilities (OU15) of the Kennecott North Zone. The Garfield Wetlands are located between Hwy-201, Hwy-202 and I-80, north of the Kennecott Smelter and Refinery facilities and west of the Magna Tailings Impoundment facility. The remedy previously selected for OU22 is focused on response action and protection measures necessary to reduce or prevent avian exposure risks from elevated concentrations of a select set of COCs in the Garfield Wetlands through the dietary pathway.

Extent of Contamination – OU22

Since remedy selection (September 2002 ROD) water, sediment and macro-invertebrates (media) have been sampled in the ponds which comprise the nesting and foraging habitat provided by the Garfield Wetlands. Springs which feed into the Garfield Wetlands have also been sampled for the noted media. The principal COC was selenium and the concern was its mobilization up the food chain through the perceived principal food item, macro-invertebrates. Of the ponds and springs that are still sampled selenium concentrations in the media collected have varied greatly and the data does not demonstrate a clear fate and transport pathway. Furthermore, the remedy has no requirements to monitor directly the potential teratogenic effects from selenium potentially expressed in the avian population. Thus there is no way on an annual basis to assess the effectiveness of a selected remedy. Lastly, the remedy did not consider other potential COCs. Recent Monitoring data has demonstrated elevated concentrations of arsenic exceeding the State of Utah's numerical water quality standard for protection of aquatic wildlife and their habitat (including their dietary supply).

Location, Setting and History – OU23

OU23 consists of the shallow, principal and bedrock aquifers underlying the Kennecott Smelter (OU13) and Refinery (OU14) facilities. Starting on the Oquirrh Mountain Range, ground water generally flows north to the Great Salt Lake from the range front.

Extent of Contamination – OU23

The 2000 – 2001 Remedial Investigation (RI) concluded that as ground water migrates north there are locations with an upward hydraulic gradient prior to the Great Salt Lake. The RI delineated the potential locations were ground water could rise and express in the springs and ponds which border or comprise the Garfield Wetlands. The RI concluded that ground water

from the shallow and principal aquifers were the predominant water supply to the surface ponds in the Garfield Wetlands. The following springs: Japanese Springs, Hansen Spring, No-name Spring, Kessler Spring, Spitz and Adamson Springs, were concluded to be the principal up-ward gradient discharge points for ground water (though up-welling locations were suspected to exist in the ponds of the Garfield Wetlands).

The RI documented the nature and extent of a selenium plume emanating from the Refinery facility. The Refinery selenium plume was assessed to extend north and under Pond 4 of the Garfield Wetlands (OU22). The RI also documented the nature and extent of an arsenic plume and a selenium plume at the Smelter facility and concluded both plumes were predominantly on Kennecott property south of Hwy-201.

2. REMEDIAL ACTIONS

The Kennecott North site was proposed for the National Priorities List (NPL) on January 18, 1994. In September 1995, UDEQ, EPA and Kennecott entered into a Memorandum of Understanding (1995 MOU). Pursuant to the terms of the 1995 MOU, Kennecott agreed to complete numerous cleanup projects for both Sites. Upon Kennecott's completion of the cleanup projects, EPA agreed to take no further action related to the final listing of the site.

2.1. OU8 Waste Water Treatment Plant and Sludge Ponds

Pursuant to EPA's June 1996 AOC and EPA's Action Memorandum For Non-time Critical Removal Action at the Kennecott North Facility Soil/Waste Water Treatment Plant Sludge Pond Site (Ref# 8EPR-SR, dated September 26, 1996), Kennecott implemented the following removal actions at OU8:

- Demolition of existing structures, followed by characterization of soils in the area of concern.
- Removal of soils exceeding the Kennecott North Zone Removal Action Levels (specified in the Statement of Work attached to the June 1996 AOC) to a depth generally not exceeding 18 inches.
- Soil demonstrating leachability (assessed via analysis of soil samples using the Synthetic Precipitation Leaching Procedure, SPLP, method 1312) was evaluated for the potential to release hazardous substances to groundwater. If a threat to groundwater was determined Kennecott could either remove the additional soils or implement other actions to mitigate releases to groundwater.
- Reclaim removal areas with appropriate backfill or engineered covers (to prevent infiltration).
- Characterize both post removal and post reclamation surfaces.

Table 1 of Appendix F summarizes specific response actions completed by Kennecott at the facilities comprising the WWTP and Sludge Ponds.

Post removal action sampling determined if the action levels under the June 1996 AOC were attained. Table 1-B in Appendix E summarizes the maximum and mean concentrations of arsenic, lead and selenium in the post removal and post reclaimed surfaces at the WWTP and Sludge Ponds.

The September 2002 ROD for Kennecott North Site specified the following response actions, in addition to the actions previously taken:

- OU23 remedy would provide requirements for the monitoring of groundwater influenced by elevated concentrations of arsenic and selenium.
- KUC would provide maps to Salt Lake County (or any annexing municipality) showing locations of buried wastes above EPA's action levels for industrial land use and for unrestricted land use.

However, as discussed in Appendix I, O&M activities and land use controls should have been required.

2.2. OU9 Magna Soils

As stated in the September 2002 ROD, the objective of a potential removal project in Magna would be to reduce or eliminate unacceptably high exposures of arsenic and lead to the residents of Magna. However, this objective was not applied in the case of Magna because no unacceptably high exposures were found during the site assessment studies. Thus Kennecott, as a potentially responsible party, was not required to take further action.

The EPA also acknowledged in the September 2002 ROD that Kennecott had pursued actions to mitigate potential future releases from the noted historical sources (Magna Tailings Impoundment – South Tailings Impoundment, OU15, and Smelter, OU13). The South Tailings Impoundment was taken off-line by Kennecott in the late 1990's and was reclaimed under the requirements of DOGM's bond #M0350002. Reclamation actions at the South Tailings Impoundment continue to date. The active impoundment (Magna Tailings Impoundment - North Tailings Impoundment, OU15) is located further to the north of the community of Magna. Operations at the North Tailings Impoundment are regulated by the DAQ under a permit and approval order (i.e. Title V Operating Permit #3500030002 and Approval Order #DAQE-AN105720026-11) and the reclamation requirements of DOGM's bond #M0350015. Smelter emissions were reduced by Kennecott bringing a new smelter on-line with better gas-handling technology. The current smelter (Outokumpu Smelter) is monitored by Kennecott under the requirements of a DAQ permit and two approval orders (i.e. Title V Operating Permit #3500030002 and Approval Orders #DAQE-AN0103460049-11 and #DAQE-AN103460052-13).

However, as discussed in Appendix I, the potential exceedances of the site's unrestricted land use standards requires a resolution.

2.3. OU13 Smelter and Acid Plants

Pursuant to EPA's June 1996 AOC and EPA's Action Memorandum For Non-time Critical Removal Action at the Kennecott North Facility Soil/Waste Water Treatment Plant Sludge Pond Site (Ref# 8EPR-SR, dated September 26, 1996), Kennecott implemented and continues to implement the following general removal actions at OU13:

- Demolition of existing structures, followed by characterization of soils in the area of concern.
- Removal of soils exceeding the Kennecott North Zone Removal Action Levels (specified in the Statement of Work attached to the June 1996 AOC) to a depth generally not

exceeding 18 inches. Current action levels are the commercial/industrial land use standards noted in Table D-3.

- Soil demonstrating leachability (assessed via analysis of soil samples using SPLP, method 1312) was evaluated for the potential to release hazardous substances to groundwater. If a threat to groundwater was determined Kennecott could either remove the additional soils or implement other actions to mitigate releases to groundwater.
- Reclaim removal areas with appropriate backfill or engineered covers (to prevent infiltration).
- Characterize both post removal and post reclamation surfaces.

Table 3 in Appendix F summarizes specific response actions completed by Kennecott at the Smelters, Acid Plants, Material and Waste Management, and Associated Facilities.

Post removal action sampling determined if the action levels under the June 1996 AOC were attained. Table 3-B in Appendix E summarizes the maximum and mean concentrations of arsenic, lead and selenium in the post removal and post reclaimed surfaces at the Smelters, Acid Plants, Material and Waste Management facilities.

The September 2002 ROD for Kennecott North Site specified the following response actions, in addition to the actions previously taken:

- Following facility closure and demolition, soils in the area are to be characterized and removed to the Arthur Step-back Repository. Generated RCRA wastes must be recycled or removed to an approved off-site facility.
- Soils to remain in place (and exceeding unrestricted land use standards) are to be covered with at least 18 inches of clean fill, graded and re-vegetated dependent upon future land use.
- Monitoring of groundwater influenced by elevated concentrations of arsenic and selenium would be covered by the remedy selected for OU23.
- KUC would provide maps to Salt Lake County (or any annexing municipality) showing locations of buried wastes above EPA's action levels for industrial land use and for unrestricted land use.
- Further CERCLA response action may be necessitated at the Former Acid Tank Farm, if the RCRA response action to address the 1991 release of acidic water is incomplete (because of the sensitive wetland environment, OU22, down gradient). Any action should prevent the migration of sulfuric acid and its residues from entering the wetland environment.

However, as discussed in Appendix I, O&M activities, compliance with State of Utah permits, and land use controls should have been required.

2.4. OU14 Refinery

Pursuant to EPA's June 1996 AOC and EPA's Action Memorandum For Non-time Critical Removal Action at the Kennecott North Facility Soil/Waste Water Treatment Plant Sludge Pond Site (Ref# 8EPR-SR, dated September 26, 1996), Kennecott implemented the following general removal actions at OU14 (and continues to do so to date):

- Demolition of existing structures, followed by characterization of soils in the area of concern.
- Removal of soils exceeding the Kennecott North Zone Removal Action Levels (specified in the Statement of Work attached to the June 1996 AOC) to a depth generally not exceeding 18 inches.
- Soil demonstrating leachability (assessed via analysis of soil samples using SPLP, method 1312) was evaluated for the potential to release hazardous substances to groundwater. If a threat to groundwater was determined Kennecott could either remove the additional soils or implement other actions to mitigate releases to groundwater.
- Reclaim removal areas with appropriate backfill or engineered covers (to prevent infiltration).
- Characterize both post removal and post reclamation surfaces.

Table 4 in Appendix F summarizes specific response actions completed by Kennecott at the facilities compromising OU14

Post removal action sampling determined if the action levels under the June 1996 AOC were attained. Table 4-B in Appendix E summarizes the maximum and mean concentrations of arsenic, lead and selenium in the post removal and post reclaimed surfaces at the refinery complex.

The September 2002 ROD for Kennecott North Site specified the following response actions, in addition to the actions previously taken:

- Following facility closure and demolition, soils in the area are to be characterized and removed to the Arthur Step-back Repository. Generated RCRA wastes must be recycled or removed to an approved off-site facility.
- Soils to remain in place (and exceeding unrestricted land use standards) are to be covered with at least 18 inches of clean fill, graded and re-vegetated dependent upon future land use.
- KUC would provide maps to Salt Lake County (or any annexing municipality) showing locations of buried wastes above EPA's action levels for industrial land use and for unrestricted land use.
- Further CERCLA response action may be necessitated at the former precious metals plant at the time of closer. At a minimum, the current cap over the former precious metals plant must be extended to cover the remaining wastes currently inaccessible underneath the current tank house of the new refinery.

However, as discussed in Appendix I, O&M activities, compliance with State of Utah permits, and land use controls should have been required.

2.5. OU15 Mills and Tailings Pond

Pursuant to EPA's June 1996 AOC and EPA's Action Memorandum For Non-time Critical Removal Action at the Kennecott North Facility Soil/Waste Water Treatment Plant Sludge Pond Site (Ref# 8EPR-SR, dated September 26, 1996), Kennecott implemented the following general removal actions at OU15 (and continues to do so to date):

- Demolition of existing structures, followed by characterization of soils in the area of concern.
- Removal of soils exceeding the Kennecott North Zone Removal Action Levels (specified in the Statement of Work attached to the June 1996 AOC) to a depth generally not exceeding 18 inches.
- Soil demonstrating leachability (assessed via analysis of soil samples using SPLP method 1312) was evaluated for the potential to release hazardous substances to groundwater. If a threat to groundwater was determined Kennecott could either remove the additional soils or implement other actions to mitigate releases to groundwater.
- Reclaim removal areas with appropriate backfill or engineered covers (to prevent infiltration).
- Characterize both post removal and post reclamation surfaces.

Table 5 in Appendix F summarizes specific response actions completed by Kennecott at the milling facilities and its associated infrastructure, and the mill waste ponds, piles, and pipelines at OU15.

Post removal sampling determined if the action levels under the June 1996 AOC were attained. Table 5-B in Appendix E summarizes the maximum and mean concentrations of arsenic, lead and selenium in the post removal and post reclaimed surfaces at the mills, mill waste facilities and associated facilities.

The September 2002 ROD for Kennecott North Site specified the following response actions, in addition to the actions previously taken:

- Following facility closure and demolition, soils in the area are to be characterized and removed to the Arthur Step-back Repository. Generated RCRA wastes must be recycled or removed to an approved off-site facility. Reclamation actions are to comply with the standards listed in the reclamation permit issued by DOGM.
- Soils to remain in place (and exceeding unrestricted land use standards) are to be covered with at least 18 inches of clean fill, graded and re-vegetated dependent upon future land use.
- KUC would provide maps to Salt Lake County (or any annexing municipality) showing locations of buried wastes above EPA's action levels for industrial land use and for unrestricted land use.

However, as discussed in Appendix I, O&M activities, compliance with State of Utah permits, and land use controls should have been required.

2.6. OU19 Smelter Fallout

Pursuant to the September 2002 ROD the following response actions were required for OU19:

- Reduce or eliminate unacceptable exposures of plants and wildlife to residual contaminants in the soils of the canyons.
- Reduce or eliminate unacceptable exposures experienced by people who might use the canyons for recreational activities in the future (such as hiking and hunting).

- Prevent migration of contaminants into sensitive habitats down gradient (such as the Garfield Wetlands).

Previous investigations determined that there was no current risk for exposure to on-site workers or potential future recreational users of the canyons. No physical response work was required by the September 2002 ROD. Risk to various wildlife species in the canyons from exposure to the COCs could be calculated. However, remediation of the soils would have resulted in massive destruction of habitat which was showing signs of recovery from the fallout of the smelters. As it pertains to Little Valley, Kessler and Black Rock Canyons, a potential of risk due to residual contamination was preferred over complete destruction of the habitat (and erosional problems that likely would have arisen).

The response action Kennecott had to implement included:

- Prevent the use of plants that can uptake selenium during revegetation efforts in the canyons.
- Map areas where the concentrations of the COCs exceed land use standards (unrestricted and industrial) or pose an increased risk of observable effects to either ecological or human receptors.
- Areas that have the potential to pose a threat dependent upon future land use were to be segregated and scheduled for appropriate response action at the time of land use change.
- If the canyon areas were to be mined for sand, gravel and/or topsoil, none of the excavated material leaving the site was to exceed the Sites' unrestricted land use standards. On-site use of material as borrow material must comply with the established land use standards for each area.

As discussed in Appendix I, due to concentrations of arsenic and lead above the site's unrestricted land use standards and exposure pathway assumptions for recreational land use, land use controls, future evaluation criteria, and mapping are necessary. Furthermore, Kennecott's compliance with Air Quality permits for its operational facilities with air emissions would ensure that ongoing emissions from operations will not have adverse impacts within the respective airsheds. Kennecott's compliance with reclamation requirements pursuant to their DOGM reclamation bonds could also assist to control the plants species which comprise the seed mixtures used during ongoing reclamation efforts.

2.7. OU22 Great Salt Lake, Shoreline Wetlands and OU23 North End Groundwater

OU22

EPA, DERR and Kennecott recently began re-evaluating the potential exposure issues in the Garfield Wetlands. Such was premised on:

- The uncertain fate and transport of selenium in the Garfield Wetlands.
- An incomplete data set (which includes minimal end point samples) to measure potential exposure effects due to elevated selenium in the dietary pathway.
- The lack of metrics to compare potentially elevated selenium concentrations in end point samples collected from the avian receptors.
- There was not an assessment done to determine if arsenic could be a COC.

OU23

The original remedy (monitored natural attenuation) required ongoing monitoring of the delineated plumes, on-going assessment of locations where ground water expresses at the surface, and capture of ground water expressed at the surface that exceeds selenium concentrations of 50 µg/L (which is a human health ARAR concentration). Furthermore, the Refinery selenium plume was to be contained using Garfield Well #5 to extract the plume along its leading edge, and required in-situ treatment of ground water with elevated selenium. Recent monitoring data collected for both OU22 and OU23 led EPA, UDEQ-DERR and Kennecott to question:

- The connectivity of Garfield Well #5 with the surrounding aquifer, the integrity of the Well's screens and its effectiveness at capturing the Refinery selenium plume.
- The current extent of the Refinery selenium plume.
- The potential for other sources of selenium and arsenic in OU23 and OU22.
- Increases in the concentration of selenium in the water expressed at certain springs down gradient of the Smelter facility.

Additionally, a recent pilot study (2008-2009) assessing the potential to create in-situ reductive zones to reduce selenium concentrations in the Smelter plume was determined to first release arsenic into solution prior to precipitating selenium out of solution