EXCERPTS FROM CERCLIS # SDD 987673985

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Section 1 Site Name, Location, and Description

1.1 Site Name and Location

The Gilt Edge Superfund Site (site) is located in the mining district in the Black Hills of South Dakota (Exhibit 1-1) in Sections 4, 5, 6, 7, 8, and 9; Township 4 North; Range 4 East; Black Hills Meridian; Lawrence County, South Dakota. Site coordinates are 44° 19' 43" north latitude and 103° 44' 28" west longitude. The site is approximately 6 miles south-southeast of the towns of Lead and Deadwood, on county road FDR 170. It is located immediately adjacent to the upper reaches of Strawberry Creek. The elevation of the mining district ranges from approximately 5,320 to 5,520 feet above mean sea level. Figure 1-1 provides an aerial photograph of the site.

Exhibit 1-1. Location of Gilt Edge Site

Due to the complex nature of the site, the U.S. Environmental Protection Agency (EPA) has organized the work into three operable units (OUs).

- **OU1, Primary Mine Disturbance Area.** Addresses existing contaminant sources within the primary mine disturbance area, such as waste rock, spent ore, exposed mineralized bedrock, and sludge.
- **OU2, Water Treatment, Groundwater, and Lower Strawberry Creek.** Addresses (1) management of acid rock drainage (ARD) generated at the site, including ARD collection systems, pumping stations, pipelines, water treatment, and management of ARD treatment sludge generated in the future; (2) groundwater contamination associated with the site; and (3) contaminant sources, surface water, and sediments in the Lower Strawberry Creek area.
- **OU3, Ruby Gulch Waste Rock Dump.** Addresses contaminant sources located within the Ruby Gulch waste rock dump.

1.2 Key Site Features

The site has been extensively disturbed by mining and mineral processing operations throughout its history, and many features associated with development remain, including open pits, extensive underground mine workings, and hundreds of rotary and core holes drilled throughout the surface of the mine that contribute to ARD. Other features include piping, impoundments, and equipment associated with mineral processing; waste rock storage facilities; and collection, conveyance, and treatment facilities to manage ARD. Six specific types of site features have a significant impact on the site:

- Open pits
- Underground mine workings
- Heap Leach Pad (HLP)
- Waste rock dumps
- Surface water management systems
- Lower Strawberry Creek

These site features are described below.

1.2.1 Open Pits

Three open pits at the site were developed during Brohm Mining Corporation (BMC) operations: Sunday Pit, Dakota Maid Pit, and Anchor Hill Pit. In addition, the Langley Benches Remediation Subarea includes three small pits. Two of these pits are located on the south side of Langley Peak and have been partly backfilled, but acidic bedrock exposures remain above the fill placement. The small pit located on the northeast side of Langley Peak was completely backfilled, covered with topsoil, and revegetated by the mining company. For purposes of this record of decision (ROD), these small backfilled pits are grouped into one remediation subarea. The large open pits are discussed below:

- **Sunday Pit.** This 31-acre pit is located in the central/southeast portion of the mine area. At the highwall, it is about 240 feet deep. The pit is currently used as an ARD storage vessel. It currently contains approximately 20 million gallons of ARD. The pit also contains wastewater treatment plant (WTP) sludge generated during 1999 and 2000, areas of waste rock backfill, extensive underground mine workings, and a relic tailings repository.

- **Dakota Maid Pit.** This 14-acre pit is located in the central portion of the site, northwest of the Sunday Pit. The pit is a side-hill pit with highwalls ranging from 50 feet to 320 feet in height. It has been used as part of the site water management system and contains about 6 million gallons of ARD. The pit is underlain by a network of underground mine workings that are accessed by the King Shaft, which is located in the base. Mine workings are also present west and south of the pit, and are accessed by several adits. The Dakota Maid also contains water treatment plant sludge, areas of waste rock backfill, and a relic tailings repository.

- **Anchor Hill Pit.** This pit is located in the northwestern portion of the site. It covers 28.6 acres and has a maximum depth of 340 feet. It currently holds approximately 80 million gallons of ARD. It was part of a treatability study assessing passive ARD treatment from 2001 to 2006. The Anchor Hill Pit is currently also used as an ARD storage vessel.

1.2.2 Underground Mine Workings

A complex network of shafts, adits, and stopes is present in the central portion of the site (Figure 1-2). These underground mine workings were developed prior to open pit mining. Most are located near the Dakota Maid or Sunday Pits. Some of these workings have been intersected during construction of the mine pits.

1.2.3 HLP

The HLP is located in the north central portion of the mine area. The HLP and the HLP Extension cover an area of 37 acres and are estimated to contain approximately 2.2 million cubic yards of spent ore. A portion of the spent ore is currently acid generating. The HLP was an integral component of the mineral processing facilities at the site and was used to irrigate the ore with cyanide solutions to dissolve gold. Spent ore is rock that has been leached to remove the gold. The spent ore pile is approximately 150 feet high and is underlain by a multi-layer liner system. Flushing and natural degradation have reduced cyanide concentrations in spent ore to trace levels.

1.2.4 Waste Rock Dumps

Mine waste rock is found in numerous areas of the site where it was used as construction fills during mine development. Areas with significant volumes of waste rock fill include the Ruby Gulch, Hoodoo Gulch, Strawberry Gulch area, Stormwater Pond, and Anchor Hill remediation subareas.

The most significant accumulation of mine waste rock is located at the head of Ruby Gulch in the east central portion of the site. It covers an area of approximately 75 acres and is estimated to contain 20 million tons (12 million cubic yards) of acid generating waste rock and spent ore. The dump is approximately 400 feet high from its crest east of the HLP to the toe in Ruby Gulch. The majority of the Ruby Gulch waste rock dump has been remediated under the OU3 Interim ROD.

Other important mine wastes are relic tailings, which were produced at the mine site prior to 1942. Tailings have been placed in repositories located in the area immediately northwest of the Dakota Maid Pit and in the eastern part of Sunday Pit. The repository northwest of Dakota Maid Pit is currently covered by a soil stockpile. Relic tailings are also present on the banks of Lower Strawberry Creek.

1.2.5 ARD Water Management Systems

Numerous ARD collection and conveyance facilities exist at the site. Generally, ARD is collected from the drainages within the site and pumped to the mine pits for storage prior to treatment. ARD is collected then transferred using pumping systems at Ruby Repository, Hoodoo Gulch, and Pond E (also known as Strawberry Pond). The ARD is pumped from these locations to the Sunday or Anchor Hill pits for storage or to the WTP for treatment.

A high-density sludge WTP was constructed and became operational in 2003. This WTP uses lime to increase pH of the water and precipitate metals as sludge. The sludge is disposed on site on the HLP Extension. The plant has a design treatment rate of 250 gallons per minute (gpm).

Section 2 Site History and Enforcement Activities

2.1 Site Background and History

Mining and mineral processing have been conducted at the site since the late 1800s. Major periods of activity occurred from 1938 to 1941, when the site was operated by Gilt Edge Mining Company, and from the mid-1980s to approximately 1997, when the site was operated by the BMC. During other periods, a number of other owners and operators, including private individuals as well as companies, have conducted a range of mining and mineral processing activities at the site.

During the last period of mining, the site was operated as a large-scale open pit heap leach gold mine. The operator, BMC, abandoned the site in July 1999. At that time, there was an imminent risk of uncontrolled discharges of acid rock drainage from the site. The State of South Dakota immediately responded and took responsibility for collection and treatment of ARD. In 2000, EPA took over primary site responsibilities. The following subsections discuss:

- Mining and mineral processing activities
- State and federal regulatory activities undertaken to address the contamination

Exhibit 2-1 depicts a summary of these activities.

2.1.1 Early Mining and Mineral Processing

Mining activities began at the site in 1876 when the Gilt Edge and Dakota Maid claims were founded. Historical underground mining operations extracted sulfide-bearing gold ores from irregular deposits in veins and fracture zones in the igneous rocks. Over the past century, a number of owners and operators have conducted a variety of mining and mineral processing activities at the site.

2.1.2 BMC Operations

The South Dakota Board of Minerals and Environment issued Large Scale Mine Permit No. 439 in 1986, approving the open pit mining operation. Initial development included construction of a HLP, a Merrill-Crowe gold processing plant, process solution ponds, and ancillary mine infrastructure. The Sunday and Dakota Maid pits were mined from 1986 through 1992. Several conditions of the permit addressed mitigation of relic mine tailings.

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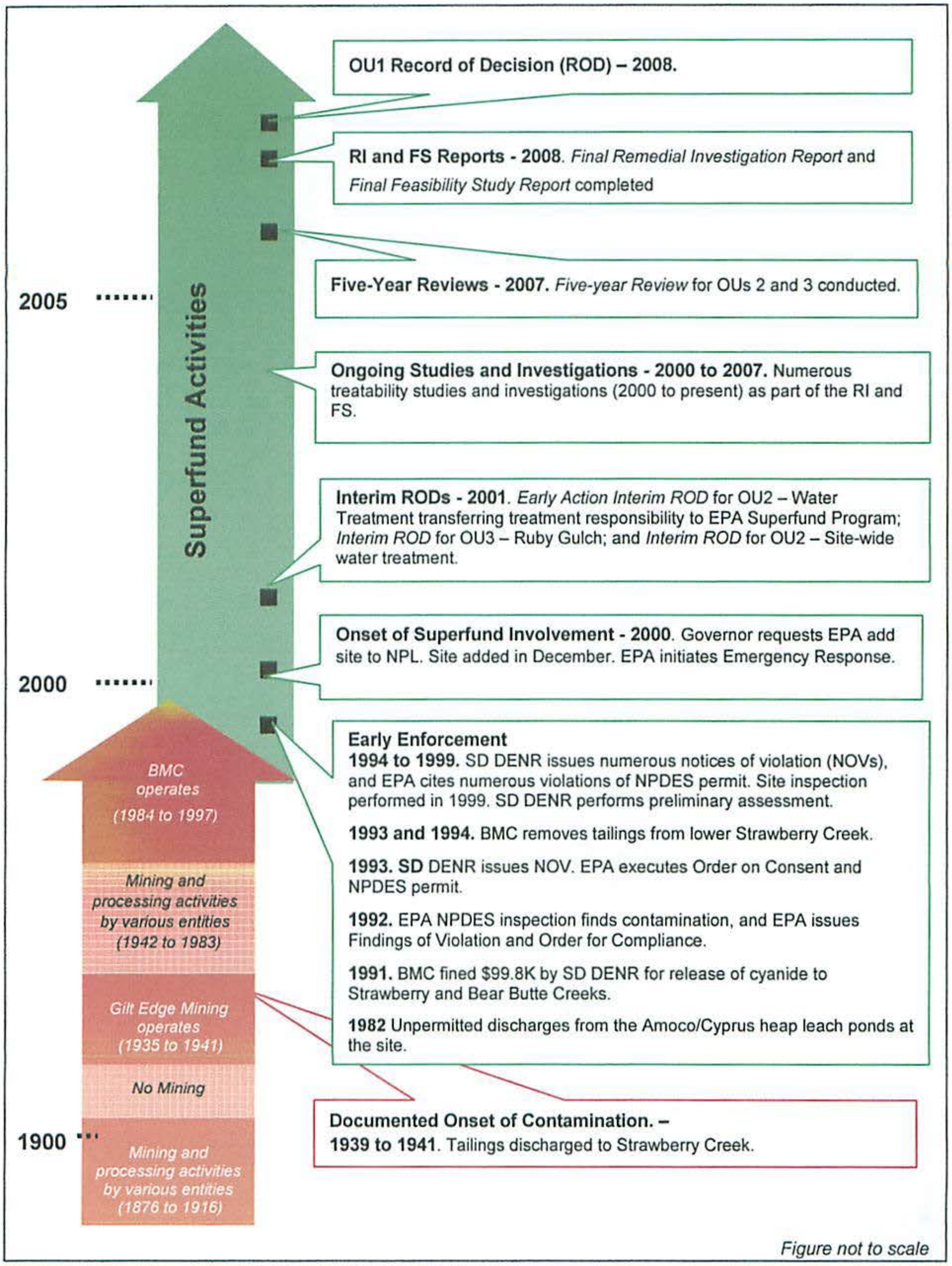
Exhibit 2-1 Timeline of Mining and Regulatory Activities at the Site



In 1991, cyanide leaked from the mineral processing circuit and affected Strawberry and Bear Butte creeks. During an EPA inspection in 1992, unpermitted discharges of acidic and metal-laden waters containing aluminum, cadmium, copper, lead, and zinc were observed and recorded. As a result, in 1993 EPA issued a National Pollutant Discharge Elimination System (NPDES) permit to BMC addressing surface water discharges.

A large-scale mining permit for mining of undisturbed rock at the Anchor Hill deposit was issued by the South Dakota Board of Minerals and Environment in January 1996. The project was split into two phases. Mining of the Phase I deposit and the portions of the Phase II deposit was initiated in May of 1996 and completed by August of 1997. In addition, the Langley Area was mined between the first and third quarters of 1997 and was not part of either Phase I or Phase II.

Mining of a portion of Phase II was delayed because of the need for an environmental impact statement, which the USFS approved in November 1997. However, in response to appeals, USFS withdrew approval in February 1998. On May 21, 1998, BMC reported that it would abandon the mine in 1 week. The state filed for a temporary restraining order to prevent abandonment. The order was granted on May 29, 1998 and was followed by a preliminary injunction on June 5, 1998. BMC's parent company, Dakota Mining Corporation, filed for bankruptcy in Canada in July 1999. As a result, SD DENR assumed water treatment operations under South Dakota's Regulated Substance Response Fund.

2.2 Regulatory Activities

2.2.1 Enforcement Actions and Documented Releases

Enforcement actions and the history of documented releases of hazardous substances are illustrated in Exhibit 2-1 and briefly described below:

- **1939 to 1941.** Tailings discharged to Strawberry Creek.
- **May 1982.** Amoco/Cyprus reports to SD DENR that the heap leach ponds overflowed during heavy rains.
- **June 20 to 21, 1991.** Cyanide used in the heap leach process leaked and was discharged to Strawberry and Bear Butte Creeks. BMC was fined $99,800 and issued a Notice of Violation (NOV) and Order by SD DENR.
- **May 19, 1992.** EPA conducted an NPDES inspection and found unpermitted contaminated water discharging from two areas. This included seepage from the toe of Ruby Gulch waste rock dump and pollutants from several point sources entering the Strawberry Creek diversion culvert through sedimentation ponds.

- **August 10, 1992.** EPA transmitted an inspection report to BMC, requiring application for an NPDES permit (EPA 2000b).
- **November 24, 1992.** EPA issued a Findings of Violation and Order for Compliance, setting forth monitoring requirements and interim performance standards for Strawberry Creek and Ruby Gulch (EPA 2000b).
- **April 19, 1993.** Based on low pH and elevated concentrations of sulfate, aluminum, copper, iron, manganese, and zinc in Ruby Gulch discharge, an NOV was issued by SD DENR (EPA 2000b).
- **September 14 and 15, 1993.** EPA executed an Order for Compliance on Consent, superseding the November 24, 1992 Order (EPA 2000b). EPA issued NPDES Permit Number SD-0026891 to BMC (EPA 2000b).
- **February 15, 1994.** SD DENR issued a letter regarding NPDES permit violations at Compliance Point 002 in Ruby Gulch for pH, cadmium, copper, and zinc (EPA 2000b).
- **March 31, 1994.** EPA issued a Notice of Proposed Assessment of Class II Civil Penalty on NPDES Permit Number SD-0026891 (EPA 2000b).
- **August 25, 1994.** EPA issued a Consent Order based on permit violations, including February 1994 violations in Ruby Gulch (EPA 2000b).
- **February 20, 1997.** SD DENR issued an NOV for the discharge of acid mine drainage into Strawberry Creek. BMC paid a total penalty of $5,400.
- **September 15, 1997.** SD DENR issued an NOV for two discharges of acid mine drainage into Strawberry Creek. BMC paid a total penalty of $18,000.
- **September 5, 1998.** SD DENR issued an NOV and Order for Compliance for NPDES permit violations (including cadmium, copper, and zinc) at Strawberry Creek Compliance Point 001 in 1996, 1997, and 1998 (EPA 2000b).
- **March 31, 1994 through January 31, 2000.** Numerous violations of NPDES permit limits at Compliance Points 001 and 002 (EPA 2000b).
- **May 18, 1999.** A preliminary assessment of the site was prepared by SD DENR.
- **1999.** UOS prepared the site inspection. Soil, sediment, and surface water samples were collected and analyzed for heavy metals and cyanide.
- **February 2000.** South Dakota requested that EPA propose the site for the National Priorities List (NPL) and provide emergency response, as well as remedial cleanup.

- **May 2000.** Site proposed for NPL.
- **December 2000.** Site listed on NPL.

2.2.2 Emergency Responses

Both the State of South Dakota and EPA have conducted emergency response activities at the site to prevent or mitigate imminent environmental threats.

2.2.2.1 State of South Dakota

After BMC abandoned the mine, the state immediately assumed site maintenance and water treatment activities using the South Dakota Regulated Substance Response Fund. The primary requirements were retaining critical staff to operate and maintain ARD collection, conveyance, and treatment systems; procuring reagents necessary for operation of the water treatment systems; and purchasing electrical power to run the ARD collection, conveyance, and treatment systems.

2.2.2.2 EPA

In August 2000, EPA took over emergency response activities from the State of South Dakota and assumed primary responsibility for ARD collection, conveyance, and treatment, as well as general site operation and maintenance. These actions are noted in Section 2.3.

2.3 Previous Remedial Actions

Three interim actions have been implemented at the site. They were intended to provide protection while investigations and studies were being conducted to determine the final remedial actions necessary to address environmental problems at the site. The interim remedial actions performed at the site are summarized below.

2.3.1 OU2, Water Treatment, Early Action Interim ROD, April 2001

This early action interim remedial action had four main objectives:

- Maintain site control and operational infrastructures
- Collect metal-laden toxic waters and ARD for treatment in existing WTP
- Upgrade the WTP with a ferric iron addition
- Implement optimized onsite sludge management using storage basins or sludge filtering equipment

Administrative building repairs were also made. Addition of ferric iron was needed to increase precipitation and co-precipitation of metals in sodium hydroxide sludge.

2.3.2 OU2, Water Treatment, Interim ROD, November 2001

The primary requirements of the interim remedial action under this interim ROD were to collect and divert ARD seep flows for treatment and to convert the existing sodium hydroxide water treatment plant to a less costly lime-based or metals-coordination treatment/filtration system.

The results of the interim action were:

- Reduced migration of metal contaminants and acid water to Strawberry Creek from Hoodoo Gulch and Pond C
- Reduced metals-contamination in surface water discharge to Strawberry Creek
- Increased net amount of ARD treatment through the WTP system to 250 gpm, reducing the threat of contaminant release to downgradient water users
- Reduced operating costs of the WTP system

Under this action, an ARD collection and conveyance system was constructed for Hoodoo Gulch and Pond C. The existing sodium hydroxide WTP was converted to a lime-based neutralization/precipitation process. The lime based, high-density sludge process was selected following pilot testing at the site. The ability of the WTP to meet total dissolved solids (TDS) and selenium water quality standards is uncertain. Because of this, these standards were waived for the short term, with the understanding that they will be addressed during final remedial actions.

2.3.3 OU3, Ruby Gulch Waste Dump, Interim ROD, August 2001

This action addressed contamination associated with what was the largest ARD source on the site at that time, the Ruby Gulch waste rock dump. It reduced the volume of contaminated materials exposed at OU3 and the infiltration that produces large quantities of ARD. Under the interim ROD, waste rock was regraded and placed in the upper Ruby Gulch drainage. A composite cap was constructed with a geomembrane liner, lateral drainage structures were installed, a protective layer was constructed for the liner and surface water controls, and surface water run-on diversion channels were constructed.

The results of the interim action were:

- Controlled erosion of mine waste into local water courses
- Controlled formation of ARD and leaching and migration of contaminants from mine waste into surface water

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- Controlled formation of ARD and leaching and migration of contaminants from mine waste into local groundwater
- Significantly reduced quantity of ARD requiring containment and treatment
- Reduced threat of release to downgradient water users

2.4 Summary of Data Sources for the Remedial Investigation and Feasibility Study

Data from numerous sources were used in the site remedial investigation (RI) (CDM Federal Programs Corporation [CDM] 2008a), which formed the basis for the feasibility study (FS) (CDM 2008b). EPA conducted site investigations during 2000 to 2006 during both the removal phase and the remedial phase. Investigations during the removal phase were conducted by URS Corporation under the EPA Superfund Technical Assessment and Response Team 2 contract. Investigations during the remedial phase were conducted by CDM and others. Historical data generated by SD DENR, BMC, and BMC consultants were also considered in the RI/FS. Numerous remedial investigations, investigations by others, pilot studies, and treatability studies were also performed under the EPA Response Action Contract and included in the site database.

The ad ran in the following newspapers:

- Black Hills Pioneer (daily) - Lead and Deadwood, SD
- Prospector (weekly) - Lead, Deadwood and Spearfish, SD
- Meade County Times (daily) - Sturgis, SD
- Lawrence County Journal (daily) - Spearfish and Deadwood, SD
- Rapid City Journal (daily) - Rapid City, SD and surrounding area

3.5 Public Comment Period

The public comment period for the Proposed Plan was initially set at 30 days (from May 23 to June 23, 2008). It was subsequently extended by 30 days to July 23, 2008 at the request of Cyprus Amax Minerals Company (CAMC).

3.6 Site Tour

On June 10, 2008, prior to the public hearing, EPA conducted a tour of the site for the Lawrence County Commissioners and other interested parties.

3.7 Public Hearing

A public hearing was held in Deadwood, SD on June 10, 2008, from 6:30 to 8:30 pm, at the Hampton Inn (531 Main Street). The hearing focused on accepting formal oral comments from the public. A stenographer recorded the hearing and was available to record any oral comments but none were given. The hearing transcript is in the Administrative Record. The agenda and one-page fact sheet prepared for this meeting are included in Appendix A.

3.8 EPA Web Site

The RI fact sheet, Proposed Plan, and public hearing date were published on the web page. The web address is www.epa.gov/region8/superfund/sites/sd.

3.9 Available Supporting Documents

The Administrative Record, including the RI and FS, was available for public review during the Proposed Plan public comment period.

3.10 Responsiveness Summary

A responsiveness summary is included as Part 3 of this ROD. EPA received five sets of comments on the Proposed Plan for OU1. EPA also received extensive comments from CAMC. EPA has organized its responses to both sets of comments by the issues raised by the commenters.

Section 3 Highlights of Community Participation

EPA conducted both required and additional community involvement and outreach activities in preparation for the release of the proposed plan. The components of EPA's Community involvement activities are outlined below.

3.1 Summary Fact Sheet

An 8-page fact sheet on the RI and the next steps (including the FS and Proposed Plan), entitled *Remedial Investigation Report Available to the Public*, was sent to EPA's Gilt Edge mailing list on February 28, 2008.

3.2 Stakeholders Meeting

In February 2008, EPA extended an invitation to meet in Deadwood for a site update. EPA contacted representatives of the South Dakota Congressional delegation (Thune, Johnson, and Herseth-Sandlin); members of the South Dakota State Legislature with districts relevant to the mine area (Maher, Olson, Brunner, McNenny, Rhoden, Apa, Hills, Turbiville, Buckingham, Schmidt, and Van Etten); the Meade and Lawrence County Commissioners; the Mayors and City Commissioners and Town Administrators of Lead and Deadwood; the Mayor and City Council of Sturgis; and a few others. As a result, EPA met with stakeholders during the week of March 17, 2008 to discuss the results of the RI and upcoming FS and Proposed Plan.

3.3 Release of a Proposed Plan

The Proposed Plan (Appendix A) was released to the public on May 23, 2008, after review and comment by SD DENR. It presented an overview of the site remedial alternatives and presented the preferred alternative for remediation. It also discussed the comment period, how to provide comment, and notice of the time and place of public meetings regarding the Proposed Plan.

3.4 Display Advertisements

A display advertisement was prepared and placed in the local newspapers after the release of the Proposed Plan. The ad announced the release of the plan and upcoming public hearing (Appendix A). The ad ran on May 23, 2008 and again on June 9, 2008 – the day before the public meeting.

Section 4 Scope and Role of Operable Unit

The OU1 remedial action builds on the interim actions implemented at the site and will be integrated into the remedy for OU2, the final site remedy. Exhibit 4-1 illustrates how the proposed remedy for OU1 integrates into the OU2 and OU3 remedies.

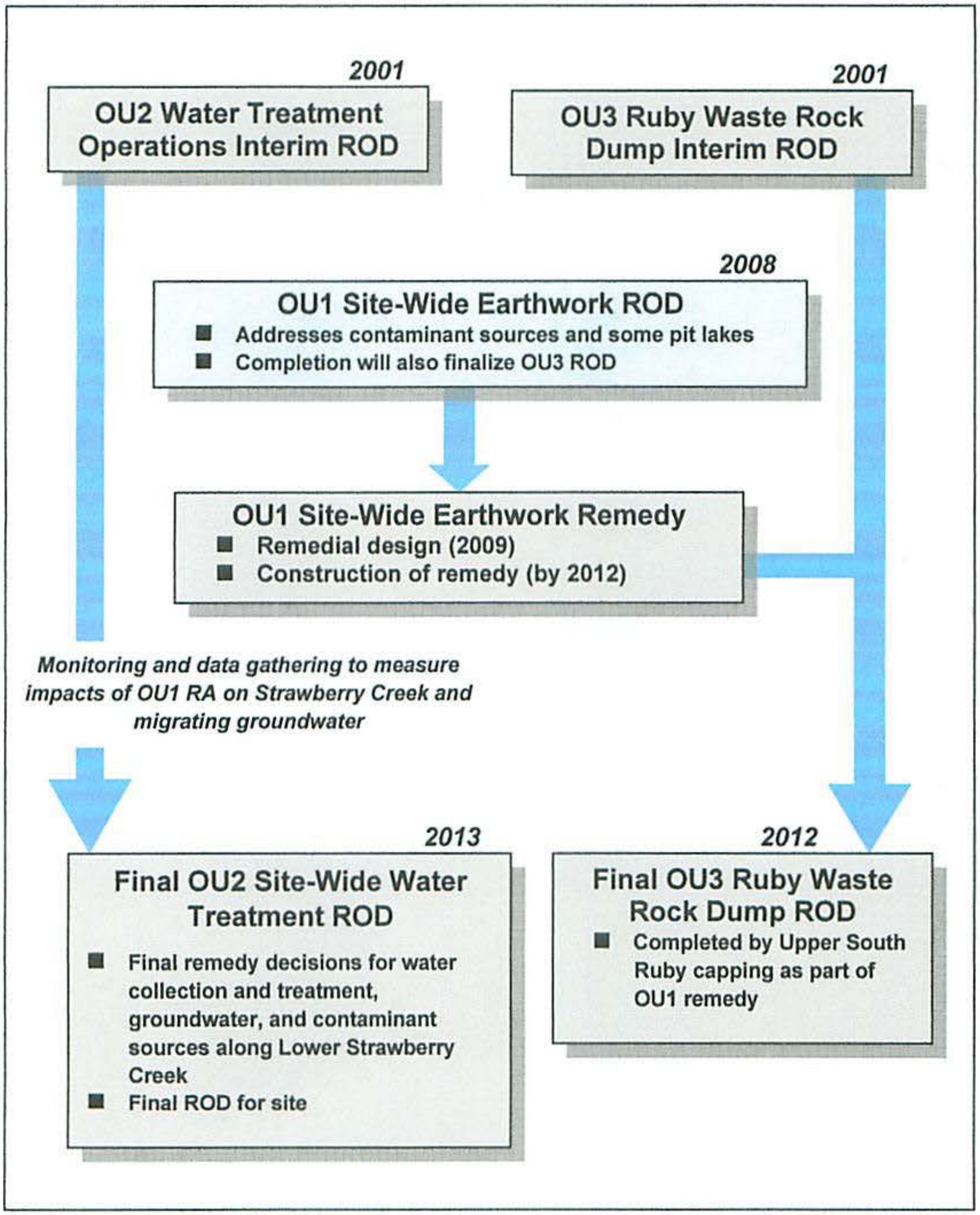
The OU1 remedial action is designed as an earthwork remedy that focuses on preventing direct exposure to mine waste with elevated concentrations of metals and the reduction of ARD generation. This action for OU1 addresses source materials including contaminated waste rock fill materials, the HLP spent ore, exposed rock surfaces, amended tailings, sludge, and underground mine workings. The remedial strategy allows for removal of mine waste from the source areas and consolidation of this waste into onsite repositories located within Sunday and Dakota Maid Pits. The onsite repositories will be capped with a cover to limit infiltration, while areas that previously contained contaminated fill or other source material will be covered with enough topsoil to support vegetation.

Another objective of the OU1 remedial action is to prevent the catastrophic release of ARD to the environment. During large storm events, the current system is not sufficient to prevent a release of ARD to Strawberry Creek, adversely impacting aquatic life and potentially threatening drinking water supplies. The consolidation and capping of the mine waste will reduce the dependence of ARD capture systems in preventing the catastrophic release of ARD from the Site.

The planned source control/earthwork activities associated with OU1 will reduce ongoing contaminant discharge to groundwater from contaminant source materials in the Strawberry Creek and Hoodoo Gulch drainages. The planned source control/earthwork activities will also reduce recharge to groundwater in Sunday and Dakota Maid pit. However, continued collection and treatment of groundwater is expected from Sunday Pit, Dakota Maid Pit, and the Ruby Repository so new subsurface infrastructure for ARD collection within the covered consolidation areas is a component of the OU1 remedy. Institutional controls will also be established as a component of the OU1 remedy to prevent unacceptable uses of groundwater that pose human risks. After the OU1 remedy is implemented and the effectiveness of the remedy is determined, a final remedy for groundwater will be identified and implemented under OU2.

Conditions within Strawberry Creek will also be monitored before, during, and after the implementation of the OU1 remedial action. The collected data will assist decision makers in determining the remedial action required in the OU2 Final ROD, which will include the final water collection and treatment plan and groundwater monitoring plan for the site. Additionally, capping of the Upper Ruby South area as part of OU1 will complete the remedial action within OU3 and finalize the OU3 Interim ROD.

Exhibit 4-1. Conceptual Sequence of Events for OUs at the Gilt Edge Site



Section 5 Summary of Site Characteristics

This section begins with an overview of the site, including a general discussion of how acid mine drainage is generated and provides a mechanism for contaminants to migrate off site. Then the site conceptual model (SCM) and a summary of the results of the RI are presented.

5.1 Site Overview

5.1.1 Size

The site encompasses an area of 1,516 acres. The primary mine disturbance area is the portion of the site that contains the contaminant sources and is the focus of the OU1 remediation. It is approximately 316 acres.

5.1.2 Climate

The climate at the site and surrounding area includes cold winter temperatures and moderate summer temperatures, with an average daily temperature of 44.2 degrees Fahrenheit. In nearby Deadwood, South Dakota, the average high in July is 79.7 degrees Fahrenheit and the average low in January is 14.3 degrees Fahrenheit. Deadwood averages 226 sunny days per year.

The site receives an average annual precipitation of 29 inches. During the months of October through mid-April, precipitation is generally in the form of snow (about 130 inches per year). April, May, and June are the wettest months, with median monthly precipitation of 3.27, 3.61, and 3.33 inches, respectively. The growing season extends from May through early September, for an average of 130 days.

5.1.3 Areas of Archeological or Historical Importance

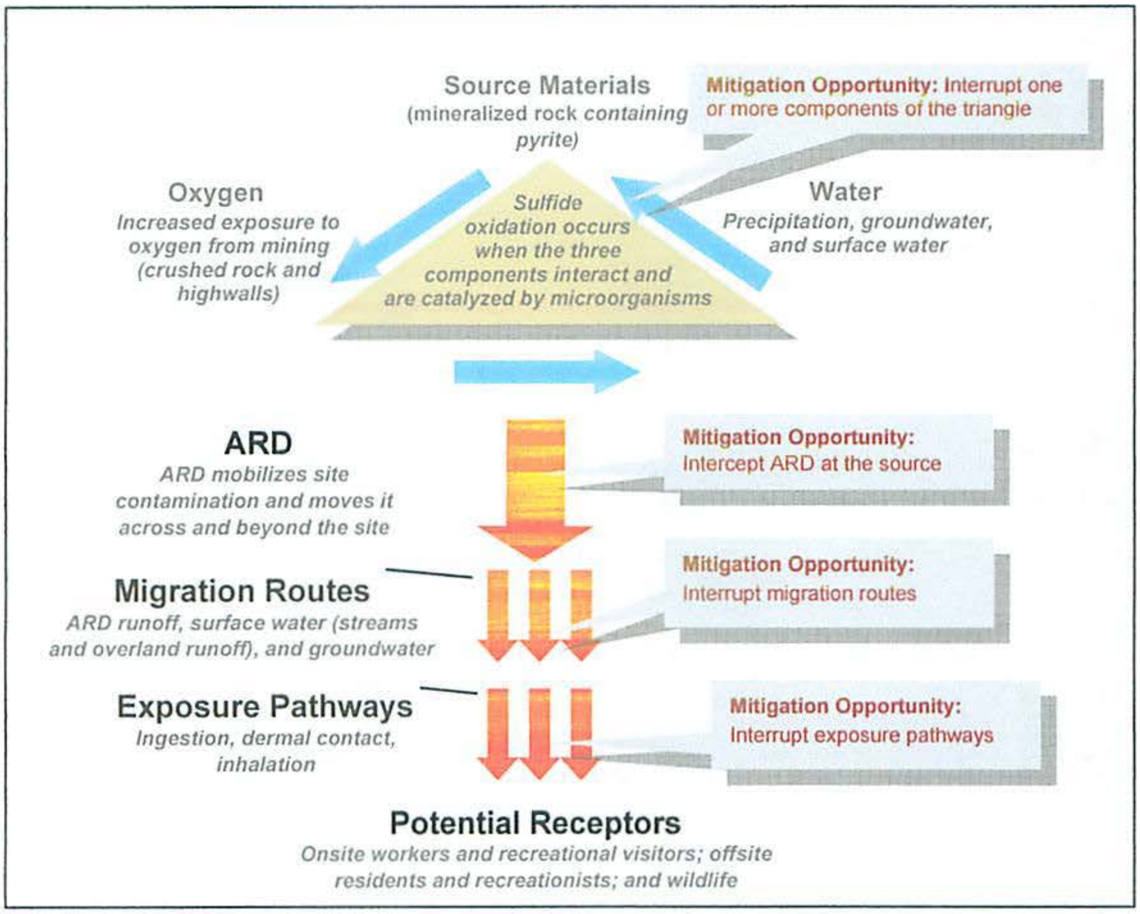
There are no known areas of archeological or historical importance within the disturbed area of the site.

5.1.4 Acid Generation, Migration, and Mitigation Model

ARD is the acidic, metal-laden water often found at abandoned gold mines. ARD is generated by the weathering of strongly mineralized rock, creating acidic water. Metals (e.g., cadmium, copper, and zinc) and metalloids (e.g., arsenic and selenium) associated with gold bearing ore are then mobilized by the acidic water. That metal-laden water then migrates into surface water and groundwater (Exhibit 5-1). ARD may often have concentrations of toxic metals that exceed acceptable standards by several orders of magnitude.

At the site, mining removed mineralized rock from deep in the oxygen-limited earth, increased its surface area through crushing and other processes, and placed it in a near-surface, oxygen-rich environment. These sources produce an average of 95 million gallons of ARD annually. The majority of ARD generated at the site is currently collected at the site and treated prior to discharge into Strawberry Creek. However, some ARD bypasses collection systems, allowing contamination to migrate from the site and has the potential to impact human or ecological receptors. In addition, the configuration of the ARD capture system is not able to capture all flows during high precipitation events. Thus, the site poses an ongoing threat for catastrophic release of toxic ARD-contaminated water.

Exhibit 5-1. ARD Generation, Migration, and Mitigation Model



5.1.5 Geology and Major Fracture Zones

Site geology is characterized by accumulations of gold and sulfide minerals in Tertiary porphyritic rocks, associated intrusive breccias, and contact metamorphic rocks formed by thermal metamorphism of the Cambrian-age Deadwood Formation. Geologic units at the site include metamorphic, igneous, and sedimentary rocks that have been extensively deformed by brittle and ductile deformation.

Structural geology is a major influence on groundwater movement. The site is located in an area where local and regional tectonic displacements occurred, and five major fractures zones have been identified with potential to contribute to off-site migration of contaminants in groundwater. These zones are approximately planar trends of numerous closely spaced and interconnected fractures. Major fracture zones cross-cut hydrogeologic units in the vicinity of Dakota Maid and Sunday Pit. These fracture zones provide potential conduits for groundwater flow. The zones are well developed in the relatively brittle intrusive units exposed in the pits.

In addition, manmade features on site (i.e., the underground mine workings and the hundreds of abandoned core and drill holes) also provide potential conduits for groundwater flow and ARD migration. Underground workings typically had no preventative measures taken against transmission of water from one area to another. Additionally, drill and core holes were often abandoned by backfilling with permeable cuttings. Surface plugs were sometimes used to slow infiltration of water from ground surface into the hole. However, surface plugs do not affect infiltration from fractures or transmissive zones penetrated by the hole.

5.2 Site Conceptual Model

The SCM is shown in Figure 5-1. It incorporates the primary mechanisms that lead to release of contaminants from source materials, migration routes of contaminants in the environment, and exposure pathways and human/ecological receptors. A brief discussion of each element is provided below.

5.2.1 Affected Media

As shown in the SCM, affected media at the site are: soil, surface water, sediment, groundwater and fish.

- **Soil.** Soil has been (and continue to be) impacted by the migration of contaminants via airborne transport of contaminated dust, runoff of contaminated surface water, or mechanical transportation of source materials (e.g., waste rock).

- **Surface water and sediments.** Surface water (Section 5.4) and sediment have been impacted by historic discharges of ARD, tailings, and sludge to onsite creeks, gulches, and ephemeral streams. Although most of these discharges have ceased, some discharge remains in the forms of runoff of contaminated stormwater. Strawberry Creek has been heavily impacted, although water quality and habitat are improving with operation of the WTP.

- **Groundwater.** Groundwater is contaminated in the primary mine disturbance area and the contamination has the potential to extend eastward toward neighboring communities and aquifers (see Section 5.5).

5.2.2 Source Materials

Source materials are primarily sources of contaminants that pose a direct exposure risk and/or have the potential to produce ARD. They are:

- **Waste rock fill materials.** Waste rock fill materials were created during construction, mine operation, and the initial phases of mine reclamation. The fills have been delineated into two groups based on ARD generating capacity (general fills and reclamation fills).

- **Exposed rock surfaces.** Exposed rock surfaces have a high potential to generate ARD. Pit highwalls encompass large areas of exposed rock that include highwalls, safety benches, and unconsolidated rock that has spalled and built up on safety benches.

- **HLP spent ore.** The HLP contains a large volume of acid-generating spent ore. This rock was processed to remove gold and is still in place on the liner system. The system reduces the potential for this rock to impact groundwater. ARD that is generated by the HLP is collected in a sump and pumped into the site water treatment circuit.

- **Amended tailings.** Amended tailings are acid generating tailings that were mitigated by amendment with alkaline fly ash, placement in repositories, capping with a low permeability clay cover, and revegetation.

- **Sludge.** Sludge is stored under varying conditions around the site. It is a source of contamination because it contains the toxic metals and metalloids that were removed from ARD during water treatment.

- **Underground mine workings.** The lower level King workings (under the Dakota Maid Pit) and the Rattlesnake workings (under Sunday Pit) are flooded with ARD on a continuous basis. The upper level King workings, which are at various points connected to the lower level King workings and the pit lake, generate acid and convey ARD towards two outfalls that currently discharge ARD (the Wood Weir and the King Adit). Discharge flow rates of ARD from the King adit and the Wood Weir correlate to water levels at the Dakota Maid and Sunday pits. Both the Wood Weir and the King Adit discharge ARD into Pond E, which is pumped to the WTP for treatment before being released into Strawberry Creek. In addition, the Langely adit discharges ARD conveyed through the Langley mine workings into Pond E on an intermittent basis.

5.2.3 Migration Routes

Three migration routes were evaluated:

- **ARD runoff.** ARD runoff occurs when precipitation interacts with ARD source materials and generates acidic metal laden water. ARD migrates from the site through the ground and over the surface.

- **Surface water migration.** Surface water migration occurs when ARD reaches area streams as site runoff or through seeps and springs. Surface water is a migration route into sensitive karst aquifers downstream of the site, which serve as drinking water sources for residential and municipal wells.

- **Groundwater migration.** Groundwater migration occurs when ARD-impacted groundwater travels through site aquifers.

5.2.4 Exposure Pathways

Exposure pathways describe the processes by which a potential receptor could contact contaminated media. The exposure pathways are:

- Ingestion of contaminated surface water, groundwater, soil, sediments, and fish

- Inhalation of contaminated surface or subsurface soil

- Dermal contact with contaminated surface water, groundwater, soil, and sediments

5.2.5 Populations That Are or Could Be Affected

Receptors define groups of humans (or other organisms) that could be impacted by site contaminants via one of the exposure pathways. One to three exposure pathways were evaluated for each receptor.

The SCM includes eight potential receptors:

- Offsite recreational fisherman

- Offsite residents

- Onsite residents

- Onsite construction workers

- Onsite commercial workers

- Onsite all-terrain vehicle (ATV) riders

- Onsite hikers

- Wildlife

Although exposure pathways were evaluated for onsite residents and ATV riders, those receptors were eliminated from the final land use at the site (Section 6) based on factors that included site characteristics and protection of the Selected Remedy.

5.2.6 Remediation Subareas

The site was divided into remediation subareas that included similar media of concern and covered a geographic area of the site (Figure 5-2). To manage these remediation subareas, an integrated remedial strategy was developed for each remediation subarea. Most of these subareas share the same contaminated media (Exhibit 5-2). A very brief description of each subarea is provided below. Aerial and ground level photographs of the subareas are shown in Figures 5-3 and 5-4, respectively.

Exhibit 5-2. Remediation Subareas and Their Associated Contaminant Sources, Surface Water Impacts, and Groundwater Impacts

Remediation Subarea	Contaminant Sources						Surface Water Impacts			Groundwater Impacts
	Acid-Gen. Waste Rock and Fill	HLP Spent Ore	Exposed Acid-Gen Bedrock	Tailings	Sludge	Mine Workings	ARD	Strawberry Creek	Bear Butte Creek	
Anchor Hill Pit	X	NA	X	NA	X	NA	X	NA	NA	X
Dakota Maid Pit	X	NA	X	X	X	X	X	NA	NA	X
Hoodoo Fill	X	NA	NA	NA	NA	X	X	X	NA	X
Heap Leach Pad	X	X	NA	NA	X	NA	X	NA	NA	NA
Langley Benches	X	NA	X	NA	NA	NA	X	X	NA	X
Process Plant	X	NA	NA	NA	X	NA	X	NA	NA	X
Ruby Repository	X	X	X	NA	NA	NA	X	NA	X	X
Lwr Strawberry Cr.	NA	NA	NA	X[1]	X	NA	X	X	X	X
Strawberry Gulch	X	NA	NA	NA	NA	NA	X	X	NA	X
Stormwater Pond	X	NA	NA	NA	X	NA	X	NA	NA	X
Sunday Pit	X	NA	X	X	X	X	X	NA	NA	X
Union Hill Upland	X	NA	NA	NA	NA	NA	X	NA	NA	X
Upper South Ruby	X	NA	NA	NA	NA	NA	X	NA	NA	X
Water Treat. Plant	NA	NA	NA	NA	X	NA	X	X	NA	NA
Groundwater	*Groundwater contamination crosses boundaries of most remediation subareas as discussed in the RI and FS.*									

[1] Streamside tailings were not addressed in OU1

NA = not applicable

- **Anchor Hill Pit Remediation Subarea.** This subarea contains a long and narrow (1,200 by 600 feet) pit, with a highwall on the northwest side that rises 300 feet above the pit floor.

- **Dakota Maid Pit Remediation Subarea.** This subarea contains underground workings, exposed bedrock, deeply penetrating fracture zones, backfilled reclamation fills, unconsolidated fill and acid-contaminated colluvium, water treatment sludge, and contaminated sediments. There is also ARD in the pit and underground mine workings, which are connected by fractures to the Strawberry Creek alluvium and regional groundwater.

- **Hoodoo Fill Remediation Subarea.** This subarea contains an 80-foot tall acid-generating fill embankment that was used to establish a haul road. There are also potentially buried underground mine workings.

- **HLP Remediation Subarea.** This subarea contains the HLP and 2.2 million cubic yards of spent ore, stockpiles of construction material, sludge storage, and a multi-layer liner system (designed to collect and convey gold processing solutions and now used to collect ARD). The northeastern portion of the extension is used to store sludge generated at the WTP.

- **Langley Benches Remediation Subarea.** This subarea contains benched areas south and east of Langley Peak, two open pits (North Langley and Southeast Langley), and fills used to construct access roads.

- **Process Plant Remediation Subarea.** This subarea contains the Process Plant building, assay lab, pump house, outdoor storage areas, and several lined ponds. ARD seepage from this area flows to the Strawberry Gulch Remediation Subarea where it is captured for treatment.

- **Ruby Repository Remediation Subarea.** This subarea contains 75 acres of the waste rock dump, with an internal cutoff wall and an outfall pipe that collects and conveys ARD seepage to a subsurface collection gallery for temporary storage prior to transfer to the Sunday Pit.

- **Lower Strawberry Creek Remediation Subarea.** This subarea includes the lower section of Strawberry Creek from the WTP discharge outlet to the confluence with Boomer Gulch. It has been impacted by tailings and by WTP sludge that was deposited along the streambed and has become embedded in the substrate.

- **Strawberry Gulch Remediation Subarea.** This subarea is the portion of the pre-mining drainage south of the Process Plant and Stormwater Pond remediation subareas west of the Dakota Maid Pit. It includes the main roadway along the former stream corridor of Upper Strawberry Creek, a series of water diversion channels and culverts, and ARD-conveyance culverts with flow regulation ponds.

The ponds function as ARD capture and conveyance locations for site-wide water treatment.

- **Stormwater Pond Remediation Subarea.** This subarea contains the lined Stormwater Pond, road and embankment fills, a road-cut excavation, topsoil stockpiles, and a piped diversion that captures and conveys unimpacted surface water runoff.
- **Sunday Pit Remediation Subarea.** This subarea includes the Sunday Pit, underground mine workings, a tailings repository, exposed bedrock, reclaimed areas of backfilled amended tailings, and underground mine workings.
- **Union Hill Upland Remediation Subarea.** This subarea includes remnants of Union Hill and the adjacent upland surfaces, as well as a fueling station used as the contractor staging area.
- **Upper South Ruby Remediation Subarea.** This subarea includes the portion of the Ruby Gulch Waste Rock Dump that was not covered during construction of Ruby Repository.
- **WTP Remediation Subarea.** This subarea includes a site-wide ARD collection, conveyance, and treatment system designed to collect and transfer site waters between impoundments (pits and ponds) and the WTP and to capture ARD for treatment in Strawberry and Hoodoo gulches.
- **Groundwater Remediation Subarea.** This subarea was developed to organize potential remedial actions that address groundwater into one area in the FS. This strategy was adopted because groundwater contamination crosses boundaries of the previously defined remediation subareas and extends out of the primary mine disturbance area encompassed by the remediation subareas. Additional definition of the subarea will be developed based on considerations of groundwater characteristics, nature and extent of contamination, fate and transport, and risks.

5.3 Sources of Contamination

During the RI, the materials in each of the remediation subarea were sampled to determine contaminant concentrations and acid generating potential.

5.3.1 Contaminant Concentrations

Materials from each of the remediation subareas were sampled to determine the concentrations of metals and metalloids. These data were used during the risk assessment to evaluate the risks of exposure to these contaminates to human health and the environment.

5.3.2 Acid Generation Potential

ARD is generated by numerous source materials, including waste rock fill materials, HLP spent ore, exposed rock surfaces, tailings, sludge, and underground mine workings. Acid generation usually starts slowly and increases as pH decreases. This is a result of an increase in the rate of bacteriological catalysis of iron and sulfur oxidation and the presence of ferrous iron in solution at low pH. When rock containing unoxidized pyrite is mined, it may display a neutral paste pH, but, as the rock oxidizes and the products of sulfide oxidation build up, it becomes increasingly more acidic.

The materials within each source area were evaluated on the basis of their *maturation*. Those with higher concentrations of sulfide oxidation products and lower paste pH are deemed more mature than those with low concentrations of sulfide oxidation products and less acidic paste pH. Strongly acidic materials are known to be acid generating and a source of ARD. Rocks that display a less acidic pH were evaluated for their future acid potential using acid base accounting methodology. The RI found that all mine waste located within the mine site boundaries were either ARD generating or had the potential to generate ARD.

5.4 Surface Water

The site is in mountainous terrain and drains toward Bear Butte Creek, a tributary of the Belle Fourche River that flows generally eastward toward the edge of the Black Hills. The site is in the headwaters of three tributaries draining into Bear Butte Creek (Strawberry Creek, Terrible Gulch, and Ruby Gulch). Strawberry Creek is a perennial stream, and Terrible Gulch and Ruby Gulch are intermittent streams. Tributary drainages contribute flow to Strawberry Creek, including Hoodoo Gulch, Boomer Gulch, Cabin Creek, and several ephemeral drainages. Surface water bodies on and near the site are shown on Figure 5-5 and described below:

- **Bear Butte Creek.** The designated uses of this creek are coldwater permanent fish life propagation waters, limited contact recreation waters, fish and wildlife propagation waters, and irrigation waters. It is listed as impaired due to temperature. Flow is highest in April, May, and June (average flows of 18.8, 23.3, and 15.1 cubic feet per second [cfs], respectively). Lowest flows are from September to February (1.4 to 1.6 cfs). Three stream loss zones (4 cfs each) are downstream of the confluence with site tributaries. Generally, all of the flow in Bear Butte Creek enters one of the three loss zones. Water that enters the loss zones reports to the Madison and Minnelusa aquifers, important regional aquifers used for residential and municipal water supplies downgradient from the stream loss zones.

- **Strawberry Creek.** This creek is located on the site's south side. It flows 2.5 miles from the major disturbance area to the confluence of Bear Butte Creek. Designated uses vary depending upon location. Downstream of the Gilt Edge Mine office, uses are coldwater marginal fish life propagation; limited-contact recreation; fish and wildlife propagation, recreation, and stock watering; and irrigation. Upstream of the office, uses are fish and wildlife propagation, recreation, and stock watering and irrigation. It is listed as impaired due to metals, TDS, specific conductivity, and pH. It has been heavily impacted by mining activities. Water quality and habitat are improving with the operation of the WTP. Highest flows occur during April, May, and June (506 gpm, 801 gpm, and 273 gpm, respectively). Lowest flows are in September through February (66 to 90 gpm).

- **Hoodoo and Ruby Gulches.** These intermittent streams flow only at certain times of the year in response to discharge from springs or short-term runoff events. The upper portions of both watersheds are contained in the site ARD collection, conveyance, and treatment system. This reduces flow in downstream portions of the streams. Flows in Hoodoo Gulch (50 feet upstream from the confluence of Hoodoo Gulch with Strawberry Creek) and in Ruby Gulch (500 feet below the Ruby Repository toe) are on the order of several gpm.

- **Ephemeral Drainages.** Pond C Tributary and the Process Area and Anchor Hill Tributaries are upgradient of the site. Water in these drainages flows only in response to large precipitation events or rapid snow melt. The drainages are above the water table. Surface water diversions are used to capture most (but not all) unimpacted surface water from upgradient drainages and convey it directly to Strawberry Creek.

5.5 Groundwater

Groundwater is contaminated in the primary mine disturbance area and ARD may be impacting groundwater in a broad area extending eastward toward Sturgis and encompassing regional aquifers (Madison and Minnelusa). These aquifers are used as private and municipal water sources. Site aquifers include bedrock and alluvial aquifers.

Bedrock aquifers are deep and occur in the four bedrock units (Layered Sedimentary and Igneous rocks, Deformation Zone Rocks, Igneous Crystalline Stocks, and Precambrian Rocks). Each unit has widely varying aquifer transmissivities. The potentiometric surface for the bedrock hydrogeologic units has been interpreted based on water level measurements (2000 to 2007). Maps show that groundwater generally flows southeast from the topographically higher portion of the site in the area of Anchor Hill toward Bear Butte Creek at a velocity of 50 to 100 feet per year.

Alluvial aquifers occur in unconsolidated Quaternary sediments located in the base of valleys, such as Strawberry Creek, Hoodoo Gulch, and Ruby Gulch. The alluvial aquifers are unconfined aquifers. The Strawberry and Hoodoo alluvial aquifers contribute to contaminant migration at the site. The alluvial aquifers are often perched above the deeper aquifers, with a zone of unsaturated rock between. These perched conditions are site specific, and the relationship between the alluvial and bedrock aquifers commonly changes in the downgradient direction.

Groundwater-surface water interactions are extensive and include natural interactions (e.g., groundwater discharges that support perennial flow in Strawberry Creek) and anthropogenic interactions created by various mine development and reclamation activities. The interactions provide important pathways for contaminant transport and are described in detail in the RI and FS reports.

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Section 6 Current and Potential Future Land and Resource Uses

6.1 Land Use

Site land is mostly private, with some federally managed land and isolated parcels of state-owned land. Nearby private land is mostly residential, and nearby public land is used for recreation (hiking, hunting, and all-terrain vehicle operation) and industry (logging and forest management activities).

6.1.1 Current Onsite Uses

Onsite uses are currently restricted to EPA-controlled Superfund activities related to the maintenance and remediation of the site.

6.1.2 Current Adjacent or Surrounding Land Uses

The site is located in a rural area of Lawrence County about 6 miles south of the towns of Lead and Deadwood, South Dakota. Private land use near the site is primarily residential, with a few small ranches and businesses in the area. The town of Galena is located at the eastern site boundary, along Bear Butte Creek, and is home to several dozen families. Additional residences are dispersed to the south, west, and north (Figure 6-1).

Private lands are subject to zoning restrictions imposed by the county, and the site and the surrounding area are presently zoned as a Park Forest District. Authorized land uses within the Park Forest District include detached single-family dwellings, cabins, and summer homes; transportation and utility easements, alleys, and right-of-way; public parks and/or playgrounds; historical monuments or structures; utilities substations; plant nursery; tree or crop growing areas and grazing lands; and other uses approved under county conditional use permits.

The county includes large areas of public land managed by the USFS and the U.S. Bureau of Land Management (BLM). Public land use includes recreational (e.g., hiking, hunting, and all-terrain vehicle operation) and industrial (e.g., logging, hazardous fuel management, and other forest management activities). Most public land is open to future mineral development under the General Mining Law, including claim staking, mineral exploration, and potential mine development.

6.1.3 Reasonable Anticipated Future Land Uses

Within the disturbed area of the site, EPA anticipates land use will be limited to those compatible with the remedy and long-term water treatment operations. If there were no remedy to consider, future recreational activities at the site might include snowmobiling, cross-country skiing, ATV use, hiking, hunting, and fishing (within the Strawberry Creek drainage). However, in evaluating potential future recreational activities at the site, the final condition of the remediated area must be considered. One of the primary methods to mitigate ARD is to limit infiltration of water into the source materials. Soil covers are an effective means for limiting water infiltration. Snowmobiling and ATV use could compromise soil covers. EPA has determined that engineered and institutional controls will be implemented to limit active recreational activities.

Based on current zoning of the site, plausible future uses also include low-density residential use. However, groundwater beneath the site is not suitable as a drinking water source without treatment. Further, steep features and capped areas at the site are not conducive to residential development. EPA has determined that it is not practical to remediate the site to meet residential use criteria because of these site conditions.

6.2 Groundwater and Surface Water Use

OU1 does not address groundwater or surface water contamination issues at the site. These issues will be addressed in a future ROD for OU2. Information on groundwater and surface water use is provided below to give a complete picture of site land use.

6.2.1 Current Groundwater Use

In the disturbed area of the site, groundwater is pumped from the Oro Fino mine shaft in the southern portion of the site for use as make-up water in the water treatment plant and for other general non-potable purposes. The estimated consumption of this groundwater is 14 to 20 gpm. There are no potential groundwater receptors within this area, as this water is not used for drinking water by site operations and maintenance personnel because of poor water quality. Bottled water is currently used on the site for drinking water.

Because of the scope of the OU1 RI/FS, no specific investigations have been conducted to evaluate current groundwater use within or near the site boundary. The location of residential structures on or near the site was identified and plotted on an aerial photo along with the site boundary on Figure 6-1. It is likely these residences use groundwater for drinking water or for irrigation. None of these residences are located near site related groundwater contamination.

6.2.2 Current Surface Water Use

Current surface water uses may include any of the uses designated by South Dakota Water Quality Standards. Strawberry Creek's designated uses are coldwater marginal fish life propagation, limited contact recreation, fish and wildlife propagation, recreation, stock watering, and irrigation. Bear Butte Creek's designated uses are coldwater permanent fish life propagation, limited contact recreation, fish and wildlife propagation, and irrigation. Other surface waters are designated as fish and

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wildlife propagation waters and irrigation waters. The extent to which these waters are used for their designated purposes is unknown.

6.2.3 Potential Future Groundwater Use

Future groundwater use within the site boundaries will likely be restricted based on the area that groundwater contamination is found. Institutional controls will be implemented to prevent the unacceptable uses of groundwater that pose human or ecological risks.

6.2.4 Potential Future Surface Water Use

Future surface water use is expected to be similar to the current uses designated by South Dakota Surface Water Quality Regulations.

Section 7 Summary of Site Risks

This section provides a brief summary of the relevant portions of the human health and ecological risk assessments that provide the basis for taking the remedial actions at OU1. The primary focus of this action is to address site risks associated with exposure with contaminated surface water, groundwater, and on-site soils.

7.1 Human Health Risk

EPA completed a baseline human health risk assessment (BRA) in July 2006 to assess potential risks to humans (both present and future) from site related contaminants present in surface soil, surface water, sediment, and groundwater. The SCM presented in Figure 5-1 represents the various exposure pathways and potential receptors evaluated in the human health risk assessment for this site. The future use determined for the site will allow for low-intensity recreational visitors and site operation and maintenance workers. While risks to ATV riders and residential site users were also evaluated in the BRA, these uses are not viable future uses at the site since these uses could affect the integrity of caps constructed over mine wastes. Thus, the focus of this discussion will summarize risks associated with low-intensity recreational users and site operation and maintenance workers. In the human health risk assessment, the primary risks were found to be associated with contaminated on-site soils and groundwater.

7.1.1 Chemicals of Concern

The chemicals of concern (COCs) identified in the human health risk assessment for groundwater and soils are presented in Exhibit 7-1. This table includes the COCs critical to this action, the range of concentrations and the frequency of detection for each COC, the exposure point concentrations, and the statistical measure for determining each COC. The data used in the risk assessment were collected during EPA's RI. The data used in the BRA were validated, evaluated and determined to be usable in the RI.

7.1.2 Exposure Assessment

The exposure assessment identified scenarios through which a receptor could contact COCs in site media and estimates the extent of exposure. The human health conceptual model (Figure 7-1) illustrates sources, potentially impacted media, exposure routes, and exposed populations at the site that were evaluated in the BRA. For this action, the primary media of human health concern are onsite soils and groundwater. This section summarizes the exposure assessment for these media.

Exhibit 7.1 Summary of COCs and Medium-Specific Exposure Point Concentrations

Exposure Point	Chemical of Concern	Minimum Concentration	Maximum Concentration	Frequency of Detection	Exposure Point Conc.	Units
Onsite Soil Direct Contact	Arsenic	10	1,400	100%	1125	mg/kg
	Thallium	0.43	900	36%	200	
Groundwater	Aluminum	3.6	930,000	85%	121	µg/L
	Antimony	0.85	36	7%	30	
	Arsenic	1	800	34%	8	
	Cadmium	0.01	1,000	63%	3	
	Copper	0.45	280,000	80%	13	
	Chromium	0.23	1,000	55%	5	
	Iron	9	1,700,000	97%	290	
	Lead	0.5	2,400	67%	2	
	Manganese	220	370,000	99%	1,430	
	Thallium	1.6	60	14%	13	
	Zinc	0.55	37,000	88%	25	

The statistical measure for all COCs is the 95 percent upper confidence interval (UCL)
mg/kg: milligrams per kilogram
µg/L: micrograms per liter

7.1.2.1 Exposure Points or Areas

An exposure point, or exposure area, is an area where a receptor (worker, visitor, or resident) may be exposed to one or more environmental media. Media selected for evaluation in the BRA were soil, groundwater, surface water, sediment, and fish tissue.

The exposure units relevant to this action are grouped by media and are:

- **Soil.** The site was divided into five exposure units that are based on current site features and are representative of the area a recreational visitor may use when visiting the site. They include the Anchor Hill and Pits (AHP), HLP, Langley Pit (LP), Pits and Crusher Area (PCA), and Ruby Gulch Waste Rock Dump.

- **Groundwater.** Groundwater exposure units were selected by pre-existing groundwater wells that were established for prior investigations.

7.1.2.2 Potential Receptors

The BRA evaluated human populations most likely to be exposed and includes hypothetical future residents, commercial workers, construction workers, and current and future recreational visitors. For this action, the risk was estimated for the following populations:

- **Onsite hikers.** Total risks from incidental ingestion of onsite surface soil, sediment, and surface water during recreational activities
- **Onsite commercial workers (current or hypothetical future).** Total risks from ingestion of groundwater and soil at some locations
- **Onsite construction workers (current or hypothetical future).** Total risks from ingestion and inhalation of surface and sub-surface soil at the site
- **Offsite residents (current or hypothetical future).** Total risks from ingestion of groundwater

No sensitive subpopulations (current or future) were identified as part of the exposure assessment. Uses that are incompatible with the remedy (e.g. ATV rider) will be prohibited through use of land use controls (LUCs) (institutional and engineering controls) to prevent damage to existing and future waste rock caps and covers. Also, residential land use will not be allowed at the site; and, therefore, onsite residential exposure and risk was not considered.

7.1.3 Toxicity Assessment

Toxicity assessments review and summarize the potential for each COC to cause adverse effects in exposed individuals. Toxic effects generally depend on inherent toxicity; exposure pathway, frequency, and duration; and the level of exposure. A toxicity assessment identifies what adverse health effects a chemical causes and how the appearance of these adverse effects depends on exposure level. Toxicity assessment is usually divided into two parts: non-cancer effects and cancer effects.

7.1.3.1 Non-Cancer Effects

All chemicals can cause adverse health effects if given at a high enough dose. But, when the dose is sufficiently low, typically no adverse effect is observed. Thus, in characterizing non-cancer effects of a chemical, the dose at which an adverse effect first becomes evident is key. Doses below this "threshold" are considered to be safe, while those above the threshold are likely to cause an effect. EPA identifies a reference dose (RfD) to be used as a conservative estimate of the threshold. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Exhibit 7-2 presents the primary target organs and health effects of concern for the 11 non-carcinogenic COCs. Those COCs are: arsenic, aluminum, antimony, cadmium, copper, chromium, iron, lead, manganese, thallium, and zinc.

Exhibit 7.2. Non-Cancer Toxicity Summary

Chemical of Concern	Chronic Sub-Chronic	Oral RfD Value	Oral RfD Units	Primary Target Organ	Combined Uncertainty Modifying Factors	Source of RfD Target Organ	Dates of RfD Target Organ
Pathway: Ingestion							
Aluminum	Chronic	1.0 x E 0	mg/kg-day	Nervous system		EPA Region III	2005
Antimony	Chronic	4.0 x E-4	mg/kg-day	Blood	1,000	IRIS	1970
Arsenic	Chronic	6.0 x E-4	mg/kg-day	Skin C/CV system	3	IRIS	1993
Cadmium	Chronic	1.0 x E-3	mg/kg-day	Kidney	1,000	IRIS	1994
Chromium III	Chronic	1.5 x E 0	mg/kg-day		1,000	IRIS	1998
Chromium VI	Chronic	3.0 x E-3	mg/kg-day	Respiratory system	900	IRIS	1998
Copper	Chronic	4.0 x E-2	mg/kg-day	GI system		EPA Region III	2005
Iron	Chronic	3.0 x E-1	mg/kg-day	GI system		EPA Region III	2005
Manganese	Chronic	4.67x E-2	mg/kg-day	Nervous system		EPA Region III	2005
Thallium	Chronic	7.0 x E-5	mg/kg-day	Liver		EPA Region III	2005
Zinc	Chronic	3.0 x E-1	mg/kg-day	Blood	3	IRIS	2005
Pathway: Inhalation							
Aluminum	Chronic	1.0 x E-3	m^3/kg-day	Nervous system		EPA Region III	2005
Cadmium	Chronic	5.7 x E-5	m^3/kg-day	Kidney		IRIS	1994
Chromium VI	Chronic	3.0 x E-5	m^3/kg-day	Respiratory system		IRIS	1998
Manganese	Chronic	1.4 xE-5	m^3/kg-day	Nervous system		EPA Region III	2005

IRIS: Integrated Risk Information System, EPA
COCs not listed in this table have no RfD information
C/CV system: Circulatory/Cardiovascular system
GI system: Gastrointestinal system

7.1.3.2 Cancer Effects

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence that the chemical does or does not cause cancer in humans. For chemicals considered known or possible human carcinogens, the second part of the assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. It is assumed that the dose response curve for cancer has no threshold. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low doses (where the slope is still linear). This is referred to as the slope factor (SF), which has dimensions of risk of cancer per unit dose.

Based on an analysis of relative bioavailability (RBA), which is the ratio of absorption from the study medium compared to absorption from site medium, in 26 test materials, an RBA of 0.5 was selected for use in the risk assessment and is considered a generally conservative default value for arsenic in soil. In the absence of site-specific data, the RBA for all chemicals in all media was assumed to be 1.0, with the exception of lead where EPA recommended a default RBA for lead in soil of 0.6.

7.1.4 Risk Characterization

The BRA characterized risks to current and future human populations of concern, consisting of residents, commercial workers, construction workers, and recreational visitors. It was performed to estimate the likelihood and nature of the potential effects to human health that may occur as a result of exposure to the COCs at the site. Risks were separated into non-cancer and cancer risks.

The following provides information on:

- EPA's Approach for Calculating Risk
- Onsite Risk Estimates
- Offsite Risk Estimates

7.1.4.1 EPA's Approach for Calculating Risk

Non-Cancer Risk

The potential for non-cancer effects is evaluated by dividing the estimated daily intake (DI) of the COC by the RfD for that chemical over similar exposure periods, as follows:

HQ = DI/RfD

where:
HQ = Hazard quotient
DI = Daily intake (milligrams per kilogram [mg/kg]-day)
RfD = Reference dose (mg/kg-day)

If the HQ for a chemical is equal to or less than 1, it is believed that there is no appreciable risk that non-cancer health effects will occur. If an HQ exceeds 1, there is some *possibility* but not a certainty that non-cancer effects may occur. This is because of the margin of safety inherent in the derivation of all RfD values. The larger the HQ value, the more likely it is that an adverse effect may occur.

Exhibit 7-3 presents the cancer toxicity data summary for the carcinogenic COCs at the site. Those COCs are arsenic, cadmium, and chromium. For arsenic, the pathways addressed are ingestion and inhalation. For cadmium and chromium, the pathway addressed is inhalation. The SFs, SF units, and weight of evidence/cancer guideline descriptions (along with source and date) are also provided.

Exhibit 7.3. Cancer Toxicity Data Summary

Chemical of Concern	Oral Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Cancer Guideline Description	Source	Date (year)
Pathway: Ingestion					
Arsenic	1.5	mg/kg-day	A	IRIS	1988
Pathway: Inhalation					
Cadmium	1.8 x E-3	m3/kg-day	B1	IRIS	1985
Chromium VI	1.2 x E-2	m3/kg-day	A	IRIS	1986

A: Human carcinogen
B1: Probable human carcinogen. Indicates limited human data are available.
IRIS: Integrated Risk Information System, EPA
COCs not listed in this table are not known to be carcinogenic and have no SF information

7.1.3.3 Toxicity Values

All toxicity values (RfD and SF values) used in the risk assessment were derived by EPA and were obtained either from the on-line database referred to as IRIS (Integrated Risk Information System) from EPA's Health Effects Assessment Summary Tables (HEAST) or from interim recommendations from EPA's Superfund Technical Assistance Center operated by the National Center for Environmental Assessment (NCEA).

7.1.3.4 Adjustments for Relative Bioavailability

Accurate assessment of human exposure to ingested metals requires knowledge of the amount of metal absorbed from the gastrointestinal tract by the body. This is especially important for environmental media, such as soil or mine wastes, because metals in these media may exist, at least in part, in a variety of poorly water soluble minerals and may also exist inside particles of inert matrix, such as rock or slag. These chemical and physical properties may tend to influence (usually decrease) the absorption (bioavailability) of the metals when ingested.

In general, the most reliable means for obtaining absorption data on a metal that is present in a particular soil or mine waste is to study the rate and extent of absorption of the metal when the material is fed to an appropriate test animal. However, such *in vivo* studies are slow and costly, and no results exist for soils from the site.

If an individual is exposed to more than one chemical, a screening-level estimate of the total non-cancer risk is derived simply by summing the HQ values for that individual. This total is referred to as the hazard index (HI). If the HI value is less than 1, non-cancer risks are not expected from any chemical, alone or in combination with others. If the screening level HI exceeds 1, it may be appropriate to perform a follow-on evaluation in which HQ values are added only if they affect the same target tissue or organ system (e.g., the liver). This is because chemicals that do not cause toxicity in the same tissues are not likely to cause additive effects.

In the case of lead, risks are evaluated using a somewhat different approach. In brief, mathematical models are used to estimate the distribution of blood lead values in a population of people exposed to lead under a specified set of conditions. Health risks are judged to be acceptable if there is no more than a 5 percent chance that an exposed individual (a child or a woman of child-bearing age) will have a blood lead level that exceeds 10 micrograms per deciliter (µg/dL). For convenience, this probability is referred to as P10.

Cancer Risk

The excess risk of cancer from exposure to a COC is described in terms of probability that an exposed individual will develop cancer because of that exposure by age 70. For each COC, this value is calculated from the DI of the chemical from the site, averaged over a lifetime (daily intake lifetime [DIL]), and the SF, as follows (EPA 1989):

$$\textit{Excess Cancer Risk} = 1 - \exp(-DIL \bullet SF)$$

Excess cancer risks are summed across all chemicals of concern and all exposure pathways that contribute to exposure of an individual in a given population. The level of total cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, EPA considers excess cancer risks that are below about 1 in 1,000,000 to be so small as to be negligible and risks above 1 in 10,000 to be sufficiently large that some sort of remediation is desirable. Excess cancer risks that range between 1 in 10,000 and 1 in 1,000,000 are generally considered to be acceptable although this is evaluated on a case by case basis.

7.1.4.2 Risk Estimates

The risks are summarized below for individual receptor groups being addressed by this remedy.

- **Hikers.** Risks from exposure to surface water, sediment, and surface soil are likely to be below a level of concern for most recreational visitors, but could be of potential concern to individuals with reasonable maximum exposure (RME) exposures, if exposure were to occur repeatedly in some locations. Non-cancer risks are driven by the incidental ingestion of metals in surface water and from the ingestion of thallium and arsenic in surface soils. Cancer risks are driven by arsenic in surface water with additional contributions from arsenic in sediment.

- **Commercial Workers.** Arsenic, lead, and other metals in groundwater and thallium in surface soil are of concern to commercial workers. Non-cancer risks to a worker with both central tendency exposure (CTE) and RME exceed a level of concern at most locations. These risks are almost entirely due to ingestion of various metals in groundwater, with additional contributions from thallium in soil. Risks from lead exceed EPA's health based goal (P10<5 percent) for a pregnant worker at three locations due to ingestion of lead in groundwater. Total cancer risks exceed 1E-04 at most locations for workers with RME to site media and at a few locations for an individual with CTE due to dissolved and total arsenic in groundwater.

- **Construction Workers.** Thallium and arsenic in soil may pose a risk to onsite construction workers during future excavation or maintenance work at the site. Non-cancer risks are above a level of concern at all locations, while cancer risks are not of concern. Non-cancer risks are due almost entirely to ingestion of thallium, with additional contributions from arsenic at some areas. Risks from lead are below a level of concern at all locations.

- **Offsite Residents.** Ingestion of groundwater from onsite wells located along creeks and channels that drain from the site is likely to pose unacceptable levels of non-cancer and cancer risk in most locations due to dissolved and suspended metals. Non-cancer risks are above a level of concern for many well locations (CTE and RME). This risk is due to numerous chemicals, including arsenic, cadmium copper, iron, manganese, antimony and thallium, with the relative contribution varying from well to well. Lead risks are not above a level of concern, with the exception of one well where the concentration of total lead exceeds EPA's health based goal (P10 < 5 percent). Cancer risks exceed 1E-04 for RME receptors at a number of wells, with all values exceeding 1E-05. This risk is due to arsenic in groundwater.

7.1.5 Uncertainty Analysis

Quantitative evaluation of the risks to humans from environmental contamination is frequently limited by uncertainty regarding a number of key data items, including concentration levels in the environment, the true level of human contact with contaminated media, and the true dose response curves for non cancer and cancer effects in humans. This uncertainty is usually addressed by making assumptions or estimates for uncertain parameters based on whatever limited data are available. Because of these assumptions and estimates, the results of risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment. The following sections review the main sources of uncertainty in the risk calculations performed at the site.

Table 6. Cost Comparison between the OU1 ROD Remedy and Modified Remedy Components.

Remedy Component	OU1 ROD Remedy 2008		OU1 ROD Remedy 2011 Revised Costs		Modified Remedy	
	Capital Cost	Annual O&M Cost	Capital Cost	Annual O&M Cost	Capital Cost	Annual O&M Cost
WTP Modifications	$553,000	NA	$678,000	NA	NA	NA
Earthwork and Capping	$57,434,000	NA	$63,475,000	NA	$60,021,000	NA
Anchor Hill Pit- Backfilling and Cover System Construction	NA	NA	NA	NA	$5,858,000	NA
Alternate ARD Storage (Impoundment at HLP)	NA	NA	NA	NA	$2,524,000	NA
Union Hill/Coverage of Dakota Maid and Sunday highwalls	NA	NA	NA	NA	$13,079,000	NA
Parent Ground Amendment	NA	NA	NA	NA	$235,000	NA
Rinsate Water Collection Basins (versatility for rinsate capture or localized treatment)	NA	NA	NA	NA	$6,129,000	
O&M for OU1	NA	$43,000		$80,000	NA	$50,000
WTP O&M -OU2	NA	Not Calculated in ROD	NA	$236,000	NA	$174,000
Site Management O&M -OU2	NA	Not Calculated in ROD	NA	$304,000	NA	$218,000
Onsite Labor/Staff Support -OU2	NA	Not Calculated in ROD	NA	$970,000	NA	$592,000
Maintenance Supplies -OU2	NA	Not Calculated in ROD	NA	$71,000	NA	$54,000
Total Costs	**$57,987,000**	**$43,000**	**$64,153,000**	**$1,661,000**	**$87,846,000**	**$1,088,000**

<u>Notes</u>:

Costs presented are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons for evaluation purposes and do not necessarily represent annual appropriations or total budgetary expenditures required.

Total capital and annual O&M costs are rounded to nearest $1,000. OU2 Annual O&M costs exclude periodic replacement of major remedy components that may be necessary over time.

OU1 O&M costs were averaged from periodic costs presented in the OU1 ROD; 2011 OU1 O&M costs includes averaged estimate for highwall spalled material removal, Modified remedy OU1 O&M costs are adjusted for inflation from 2008 ROD.

Costs were revised during the design process in 2011 based on additional information that was gathered during the design work.

Costs developed in past years are not adjusted reflect inflation to 2014 dollars.

The scope of earthwork components for the OU1 ROD Remedy is based on the descriptions presented in the ROD.

The scope of earthwork components for the Modified Remedy includes additional sources of contaminated backfill is based on the descriptions presented in this ESD.

Reductions of O&M costs presented for the modified remedy include the expectation that generation of impacted rinsate water will be prevented.

NA - Not Applicable