F I N A L

MIDNITE MINE FEASIBILITY STUDY REPORT

Prepared for
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

September 2005

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Contract No. 68-W-98-228
Work Assignment No. 018-RI-CO-102Q

FINAL
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FOR
MIDNITE MINE
STEVENS COUNTY, WASHINGTON

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
AMD	acid-mine drainage
AOI	area of interest
ARAR	applicable or relevant and appropriate requirement
ARD	acid rock drainage
ATSDR	Agency for Toxic Substances and Disease Registry
BERA	baseline ecological risk assessment
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM	benchmark
BMP	best management practice
BOR	Bureau of Reclamation
$CaCO_3$	calcium carbonate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
COPC	contaminant of potential concern
CWA	Clean Water Act
cy	cubic yard
DMC	Dawn Mining Company
DOH	State of Washington Department of Health
E&E	Ecology and Environment
EcoRA	ecological risk assessment
EIS	environmental impact statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
Fe	iron
FML	flexible membrane liner
FONSI	Finding of No Significant Impact
FR	Federal Register
FS	feasibility study
FWS	U.S. Fish and Wildlife Service
gal	gallon
GCL	geosynthetic clay liner
gpm	gallons per minute
GRA	general response action
HELP	Hydrologic Evaluation of Landfill Performance
HHRA	human health risk assessment
HSCA	Hazardous Substances Control Act

ABBREVIATIONS AND ACRONYMS
(Continued)

H:V	horizontal to vertical
LLRW	low-level radioactive waste
MA	mined area
MAA	mining-affected area
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MOA	memorandum of agreement
msl	mean sea level
µg/L	micrograms per liter
NAGPRA	Native American Graves Protection and Repatriation Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NMC	Newmont Mining Corporation
NPDES	National Pollutant Discharge Elimination System
NPL	national priorities list
NPS	National Park Service
NRC	Nuclear Regulatory Commission
O&M	operations and maintenance
OSWER	Office of Solid Waste and Emergency Response
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
$pCi/m^2/s$	picoCuries per square meter per second
PCP	Pollution Control Pond
PIA	potentially impacted area
PRB	permeable reactive barrier
PRG	preliminary remediation goal
PW	present worth
RAO	remedial action objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SLERA	screening level ecological risk assessment
SMI	Shepard Miller, Inc.

ABBREVIATIONS AND ACRONYMS
(Continued)

TBC	to-be-considered
TDA	Tailings Disposal Area
THPO	Tribal Historic Preservation Officer
Tribe	Spokane Tribe of Indians
TIR	total ionizing radiation
ug/L	micrograms per liter
U_3O_8	uranium oxide
U	uranium
UMTRCA	Uranium Mill Tailings Radiation Control Act
uR/hr	microrems per hour
USDOE	U.S. Department of Energy
USFWS	U.S. Fish and Wildlife Service
UTL	upper tolerance limit
WAC	Washington Administrative Code
WMA	waste management area
WTP	water treatment plant
ZVI	zero-valent iron

1.0 INTRODUCTION

This document is the feasibility study (FS) portion of the Midnite Mine remedial investigation/ feasibility study (RI/FS). The Midnite Mine is an inactive hard rock uranium mine on the Spokane Indian Reservation in Stevens County, Washington. It is located approximately 35 miles northwest of Spokane and 6 miles northwest of Wellpinit, Washington, as shown in Figure 1-1.

1.1 PURPOSE AND ORGANIZATION

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the FS serves as the mechanism to develop and evaluate remedial action alternatives. This FS has been developed following the U.S. Environmental Protection Agency (EPA) guidance on CERCLA, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final* (EPA 1988), and provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] 300).

Under CERCLA, the FS is only part of the remedy selection process. The FS develops and evaluates a range of remedial alternatives that provide information needed by risk management decision makers to help formulate a Proposed Plan. The Proposed Plan includes a "preferred alternative." Following public and stakeholder review and input on the Proposed Plan, a remedy is selected and documented in a Record of Decision (ROD). The selected remedy documented in the ROD then forms the basis for remedial design and subsequent remedy construction, termed remedial action. The FS only supports the remedy selection process. It does not recommend or choose a preferred alternative, and it does not select or design a remedy. The CERCLA FS process and its relationship to the Proposed Plan and ROD are summarized in Figure 1-2.

The alternatives developed in the FS are not mutually exclusive choices and do not limit the choice of a remedy. The preferred alternative, as developed in the Proposed Plan, or, subsequently, the selected remedy, as developed in the ROD, can mix the elements of the various alternatives developed in the FS, refine or modify those elements, or add to them. Although the FS supplies information for helping select a remedy, information supplementing the FS may be incorporated into the remedy selection process at any time.

To achieve its purpose, this FS accomplishes the following tasks, which define its scope:

- Integrate and interpret information from the RI (EPA 2005), the human health risk assessment (EPA 2004a), and the ecological risk assessment (EPA 2004b) to determine whether and where remedial actions may be necessary to protect human health and the environment

- Identify potentially applicable or relevant and appropriate requirements (ARARs)
- Propose remedial action objectives (RAOs) based on ARARs and preliminary remediation goals (PRGs)[1]
- Develop remedial action alternatives that could achieve the RAOs
- Evaluate the alternatives against seven of the nine CERCLA and NCP criteria

The seven CERCLA and NCP evaluation criteria (EPA 1988) include overall protection of human health and the environment; compliance with ARARs; long-term and short-term effectiveness; reduction of toxicity, mobility, or volume through treatment; implementability; and cost. The remaining two CERCLA and NCP criteria, state (or Tribal) acceptance and community acceptance, are addressed in the ROD as part of remedy selection, which follows public review of the preferred alternative identified in the Proposed Plan.

Consistent with EPA's RI/FS guidance (EPA 1988), potential ARARs, RAOs, and PRGs were identified, as discussed in Section 2. Remedial technologies were identified, screened, and in some cases eliminated, based on technical applicability, effectiveness, implementability, and relative cost (EPA 1988), as discussed in Section 3. Based on results from Section 3, remedial alternatives were developed and screened based on effectiveness, implementability, and cost, as discussed in Section 4. The remedial alternatives, representing a range of options for potential cleanup actions, are described and evaluated, consistent with EPA's RI/FS guidance, in Section 5. The methodology used in this evaluation, including the seven evaluation criteria, is also described in Section 5.

This FS builds on two earlier FS draft technical memoranda and input from stakeholder groups. The first technical memorandum (EPA 2003a) provided early identification of potential ARARs, preliminary RAOs, and potential PRGs. Information in this technical memorandum has been updated and is presented in Section 2. The second technical memorandum (EPA 2003b) described candidate alternatives and screened those alternatives based on effectiveness, implementability, and cost. Based on this screening evaluation, selected alternatives were retained for detailed evaluation in the FS. Information in this technical memorandum is summarized in Section 4. In addition to these technical memoranda, the results of the technology identification and screening were made available on EPA's Midnite Mine website. This information is described in Section 3.

1.1.1 Stakeholders and the FS Process

EPA established a discussion group of stakeholders for technical input as the FS developed. Stakeholders who participated in the group included the Spokane Tribe of Indians (Tribe), The Colville Confederated Tribes, Dawn Mining Company (DMC), the U.S. Bureau of Land

[1] Final ARARs, RAOs, and remediation goals are officially established only in the ROD.

Management (BLM), the State of Washington Department of Health (DOH), the U.S. Fish and Wildlife Service (USFWS), and the U.S. National Park Service (NPS). The Bureau of Indian Affairs (BIA), Newmont Mining Corporation (NMC), the Agency for Toxic Substances and Disease Registry (ATSDR) and U.S. Bureau of Reclamation (BOR) were not regular participants but were included in the mail list for draft documents and meeting notes. Each of the stakeholders was provided an opportunity to review the draft technical memoranda.

In addition to the FS discussion group, EPA consulted with the Tribe throughout the development of the FS. In early 2004, the Tribe initiated formal dispute with EPA pursuant to a Memorandum of Agreement (MOA) between EPA and the Tribe. Additional technical discussions have taken place in the context of dispute resolution efforts.

Since the site for which response action alternatives were developed for this FS is on the Spokane Indian Reservation, the United States will take into consideration the impact of the response action on the Spokane Tribe, its people, and its resources. This includes consideration of the fact that the Spokane Reservation is the permanent homeland of the Spokane Tribe and that the reservation is comprised of finite resources on which present and future generations of the Spokane Tribe depend to sustain themselves, their resources and their lifeways in perpetuity.

Specific concerns that the Spokane Tribe has expressed include:

- Cleanup of groundwater and surface water due to the critical role all reservation waters play in the Tribe's subsistence, religious and cultural practices
- Any residual risks to tribal members and any impacts on tribal resources
- Long-term water treatment, including the physical, financial and other burdens it could impose on the Tribe and the risk of failure due to unmet funding or technical needs
- Restrictions on Tribal uses that impact the Tribe's long-term use of its reservation property and resources, and the needs of the reservation environment
- The need for long-term operations and maintenance (O&M) and the burden it could impose on the Tribe
- The effective loss of its reservation land base and other resources on which the Tribe will depend in perpetuity

EPA will fully consider the concerns of the Spokane Tribe relating to impacts of the alternative response actions on Tribal human health, natural resources, and environments as it evaluates and selects a remedy for the Midnite Mine Superfund Site.

EPA Indian Policy provides that "[i]n carrying out our responsibilities on Indian Reservations, the fundamental objective of the Environmental Protection Agency is to protect human health

and the environment. The keynote of this effort will be to give special consideration to Tribal interests in making Agency policy, and to insure the close involvement of Tribal Governments in making decisions and managing environmental programs affecting reservation lands." See EPA Policy for the Administration of Environmental Programs on Indian Reservations dated November 8, 1984. In 1994, EPA issued an Action Memorandum stating that "the Agency, in carrying out its statutory and trust responsibilities, must work, in partnership with Tribes, on a government to government basis, to ensure the protection of Tribal human health, natural resources and environments."

Although EPA retains final authority over and responsibility for its actions, the EPA Indian Policy recognizes Tribal governments as "the most appropriate authority for managing Tribal environments and the Agency should accord great deference to Tribal priorities and environmental goals when carrying out these activities." See Tribal Operations Action Memorandum, July 12, 1994. On September 17, 2004, EPA reaffirmed its Indian Policy recognizing the rights of Tribes as sovereign governments to self-determination and acknowledged the Federal government's trust responsibility to the Tribes. In doing this, EPA recognized that the United States has a unique legal relationship with Tribal governments based on the Constitution, treaties, statutes, Executive Orders and court decisions. See Indian Policy Memo dated September 2004.

1.2 BACKGROUND INFORMATION

1.2.1 Site Description

The Midnite Mine site is located on the Spokane Reservation in eastern Washington. It consists of the Mined Area (MA) and other mining-affected areas (MAA). These areas are shown on Figure 1-3. The MA is defined as the area where the surface has been disturbed by historical mining operations conducted between 1955 and 1981 (SMI 1996) and encompasses approximately 350 acres. The surface elevations of the MA range from 2,400 to 3,570 feet above mean sea level (msl) (SMI 1996). The major features of the MA are shown on Figure 1-4 and include:

- Areas of waste rock
- Ore and protore stockpiles
- Former open pits that have been backfilled with waste rock
- Two open pits, Pit 3 and Pit 4, that are partially filled with water
- Other surface water, including surface impoundments, seeps, and ditches
- A water treatment plant (WTP) and associated seep collection sumps and weirs
- Access and haul roads and mine buildings, including a shed of mine cores

The MAA consists of areas impacted by the environmental transport of mining contaminants and includes surface water and sediment in the Northeastern, Eastern, Central, Western, and Far West Drainages and Blue Creek downstream of the mine drainage confluence; impacted groundwater along the drainages; and surface materials in the haul roads, including impacted areas adjacent to the haul roads.

A limited number of samples of sediments in the Blue Creek delta in Lake Roosevelt have been collected. These samples do not support a definitive conclusion of whether these sediments have been affected by mine operations. Additional sampling of depositional areas would be necessary to evaluate whether sediment transport has led to unacceptable levels of contamination and to assess their source(s). For FS purposes, the delta sediments have been retained as an affected medium for development of remedial alternatives (pending the results of further analyses).

1.2.2 Site History

1.2.2.1 Mine Operations

Uranium was discovered on the site in 1954. The mine was developed and operated by DMC. The Midnite Mine was leased by DMC from the Spokane Tribe and tribal allotment owners in 1954 to produce uranium for the Atomic Energy Commission (AEC). Mining began in early 1955 and continued until 1965, when the DMC contracts with AEC expired. Mining resumed in 1969 under commercial contracts and continued until November 1981 (SMI 1996).

While estimated quantities vary, it is reported that approximately 5.3 million tons of ore and protore were mined at the Midnite Mine from 1955 to 1981 (SMI 1996). Of this total, 2.9 million tons of ore were processed at the DMC mill in Ford, Washington. The remaining 2.4 million tons of ore and protore were stockpiled at the site, where it currently remains. In addition to the ore and protore, approximately 33 million tons of waste rock were mined and disposed of in piles at the site (SMI 1996). The ore processed at the mill averaged 0.2 percent uranium oxide (U_3O_8). Approximately 11 million pounds of U_3O_8 were recovered at the DMC mill during the life of the mine (SMI 1996).

While the mine was active, nine pits or subpits were excavated. As mining progressed, several of these pits were subsequently backfilled with overburden and waste rock material. Two pits (Pit 3 and Pit 4) remain open and collect water, and an early Adit Pit is partially backfilled. A detailed description of the development of the pits, waste rock piles, ore stockpiles, and other mine features is provided in Peters (1999), who used historical aerial photography of the site to investigate the sequence of mining activities.

The BIA terminated mining leases held by DMC in 1991, but continued the companies' obligation for site management and reclamation. Although mining was discontinued in 1981, DMC has remained on site to perform limited reclamation work and operate the WTP.

1.2.2.2 Reclamation and Enforcement History

In 1979, DMC constructed the pollution control pond (PCP) at the toe of the South Spoils waste rock pile within the Central Drainage to contain water seeping from the largest of the waste rock dumps. In 1981, in response to the growing quantities of water contained in the PCP, DMC installed pumps to pump excess water from the PCP to Pit 3.

DMC performed partial reclamation of the South Spoils side slopes in 1980 by placing approximately 8 inches of stockpiled topsoil over the south-facing slopes (SMI 1996, E&E 1998). The topsoil was seeded with a mixture of grasses and planted with trees. In 2002, vegetation growing on the South Spoils slopes consisted of a mixture of grasses, small shrubs, and a few small Ponderosa pine trees.

In 1987, DMC and EPA entered into a consensual Compliance Order that required DMC to eliminate discharges of pollutants to waters of the United States. In response to the Order, DMC constructed a pumpback system to collect water from the Western Drainage and Central Drainage. A collection system had been previously installed at the East (Boyd) Seep in 1978.

In 1988, DMC constructed the WTP to treat the growing quantities of water contained in the PCP and Pit 3. The WTP can treat a maximum of 500 gallons per minute (gpm) using barium chloride precipitation of radium, application of hydrated lime to precipitate heavy metals and uranium, and final clarification to reduce suspended solids. The BLM, which was the primary federal agency managing the lease after the mine closed, issued a Mine Order on December 9, 1991, that required DMC to begin dewatering Pit 3 and Pit 4 and treating the water to the discharge quality specified in the 1985 National Pollutant Discharge Elimination System (NPDES) permit. The WTP began operations in October 1992.

The BIA terminated the DMC mining leases in 1991, and DMC submitted a reclamation plan on July 12, 1991 for the closure of the Midnite Mine (SMI 1991). This initial reclamation plan was not accepted by the agencies.

In the mid-1990s, BIA sought Bureau of Mines and other technical support for several studies of mine conditions and reclamation options. In 1995, the BLM initiated scoping of the studies for an environmental impact statement (EIS) for mine reclamation under the National Environmental Policy Act (NEPA). In 1996, DMC produced a revised site Reclamation Plan (SMI 1996). NMC and DMC agreed to conduct limited work in an interim 1998 agreement with BLM (BLM 1998). The interim studies are described in the Work Plan for the Midnite Mine (SMI 1998). The field work was conducted in 1999 and 2000, followed by data reporting in 2000 and 2001.

EPA completed an expanded site investigation (ESI) to support the potential listing of the site on the NPL in 1998 (E&E 1998). EPA proposed the site to the National Priorities List (NPL) in February 1999 and initiated negotiations with DMC for conducting an RI/FS. These negotiations

failed, and EPA began work on a CERCLA RI/FS using fund monies concurrent with the work conducted by SMI. The NPL listing was finalized in May 2000.

On December 20, 1999, the BLM (BLM 1999) issued a Finding of No Significant Impact (FONSI) for the Backfilled Pit Dewatering Plan (SMI 1999), which was part of the work specified in the 1998 agreement between DMC, the U.S. Department of Justice, and BLM. The agreement required DMC to dewater the backfilled Boyd Pit and Pit 2 and to monitor the effects on downgradient seeps. In addition, the FONSI required DMC to build a fence on the access road to Pit 3; monitor wildlife access to the pits, PCP, and the Western Drainage seeps; and leave a minimum of 3 feet of water over the sediments in Pit 3 and Pit 4. Monitoring for the Backfilled Pit Dewatering Plan began in 1999 and was completed in 2001.

1.2.3 Nature and Extent of Contamination

The nature and extent of mining-related contamination was evaluated by comparing background concentrations of indicator parameters to measured concentrations within potentially mine-affected areas.

The indicator parameters are a short list of contaminants that are indicators of acid-rock drainage (ARD) or that drive risk, were detected widely at elevated levels, and correlate with concentrations of other non-indicator contaminants. Figures 1-5 through 1-9 show the extent of mining-affected surface water, sediment, groundwater in alluvial and unconsolidated materials, groundwater in bedrock, and surface and subsurface materials, respectively.

To define areas potentially needing cleanup with a relatively high confidence, EPA compared site data to an upper statistical threshold of the data from the background areas. The comparison relied on a statistical approach intended to balance the chance of overestimating impacts (where an unaffected area appears affected) against the chance of underestimating impacts (where an affected area appears unaffected). Generally, however, near the edges of a contaminated area site conditions approach background conditions, increasing the uncertainty in comparing the two. EPA may thus have underestimated or overestimated areas near Midnite Mine where concentrations of metals increased due to mining.

Selection of different areas to represent site background conditions, collection of additional or different samples in the area used, and use of different statistical thresholds for assessing changes in conditions caused by mining could result in different but similarly valid conclusions. As required by CERCLA, EPA is focusing on areas where, despite natural variability, the data demonstrate that mining impacts have occurred and that the associated risks to human health and the environment warrant response actions.

1.2.4 Contaminant Fate and Transport

This section summarizes the RI findings regarding the fate and transport of contaminants of potential concern (COPCs) at the site. A more detailed discussion is provided in the RI (EPA 2005).

During mining operations from 1955 to 1981, relatively few environmental controls were in place at the site. This allowed substantial migration of contaminants, primarily by surface water and sediment transport along natural drainages. Beginning in 1978, DMC implemented a number of source control and reclamation activities at the site, including recontouring and covering of portions of the South Spoils; other sediment control measures along the MA boundary; and a seep collection, pumpback, and water treatment system to reduce off-site migration of contaminants.

The potentially significant migration pathways from mine-related sources to potential receptors in the MA, and from the MA contaminant sources to the MAA are:

- Surface water and sediment transport pathways
- Groundwater transport pathways
- Air transport pathways

The fate and transport of COPCs along each of these pathways are discussed in each of the following subsections.

1.2.4.1 Surface Water and Sediment Transport Pathways

Within the MA, the large open pits created by mining form hydrologic sinks for direct precipitation and surface water runoff from upgradient areas, although much of the upgradient water is now channeled and diverted. Erosion of the steep walls of the open pits, stormwater runoff into the pits, and particulates settling out of backpumped seep water are now the principal mechanisms for COPCs to be transported in surface water and deposited in sediment within the MA.

Historically, surface water runoff distributed COPCs in alluvial sediments downstream of the MA. Mine-affected surface water is present in the Northeastern, Eastern, Central, Western, and Far West Drainages. In addition, mine-affected sediments exist in each of those drainages. Even though the concentrations and number of contaminants generally decrease with distance downstream from the MA, sediments containing mine-related contaminants above background levels extend into Lower Blue Creek.

During the past 25 years, DMC has implemented measures to reduce surface water flow and sediment transport. Under current conditions, the principal migration routes for surface water and sediment leaving the MA are:

- A portion of the snowmelt and storm flow runoff bypasses the sediment detention dam in the Northeastern Drainage
- Sheet flows from storm events cause erosion and slope wash of sediments from the eastern side of the Pit 4 Dump to migrate eastward past the MA boundary
- A portion of the snowmelt and storm flow runoff bypasses the seep collection pumpback systems in the Western Drainage, at the Blood Pool, at the Dam Toe Seep, and at the East Seep areas
- Storm runoff from the western portion of the area containing the former vehicle shop and mine offices transports sediment into the Far West Drainage

1.2.4.2 Groundwater Transport Pathways

COPCs are found in groundwater present in both unconsolidated material and bedrock beneath the site. Flow paths in the unconsolidated materials convey a relatively large portion of the affected groundwater because the bedrock has much lower hydraulic conductivity. Groundwater also interacts with surface water in many areas of the MA and MAA. The groundwater flow system and its interaction with surface water are described in detail in the RI (EPA 2005) and the Phase 1 Hydrologic Modeling Technical Memorandum (EPA 2002a). In general, wherever surface water drainages or standing water elevations are higher than the groundwater table elevation, there is potential for downward percolation of surface water into the groundwater flow system. Conversely, in topographic depressions and surface drainages where the water table is equal to or higher than ground surface, shallow groundwater has the potential to flow out of the ground surface, where it is either consumed by evapotranspiration or enters the surface water flow system.

In the MA and MAA, groundwater flow is generally southward, with downward vertical gradients within the MA where large areas of bare rock, waste rock, and ore/protore contribute contaminants to groundwater. In these areas precipitation infiltrates, oxidizes sulfide minerals, and dissolves metals and radionuclides as the recharge water percolates downward and into the groundwater flow system. Groundwater containing COPCs flowing past the southern MA boundary tends to converge toward the axes of the Eastern, Western, and Central Drainages, and then continues to migrate parallel to each drainage. Further south, upward hydraulic gradients cause shallow groundwater to discharge into the surface water flow system.

The 9-inch soil cover on the South Spoils reduced surface water and groundwater impacts to some extent, and the seep collection and pumpback systems further helped reduce contaminant migration. However, water accumulating in the pits eventually threatened to overtop. In 1992,

the mining companies began pumping and treating the mine-affected water from the open pit lakes. Pumping and treatment of water from the open pits reduces the volume and mobility of COPCs in groundwater beneath the MA. Drawdown of groundwater caused by pumping of the pits, and the westerly hydraulic gradient imposed by pumping of Pits 3 and 4, creates capture zones that extend eastward from the pits beyond the eastern boundary of the MA. Despite the water management measures, including pit pumping and seepage control, several pathways still remain for migration of mine-affected groundwater beyond the MA boundary.

The groundwater flow paths (consisting generally of percolation and downward flow through COPC source areas followed by lateral migration and then upward flow to surface water) tend to cause some groundwater containing COPCs to bypass the various pumpback systems by moving beneath the systems' vertical capture zones. Under current conditions, the principal pathways for affected groundwater to migrate beyond the MA are:

- Southeast toward the East Dump Fork and East Seep areas, where a portion of the groundwater containing COPCs bypasses the Blood Pool, East Seep, East Dump Fork Seep pumpback systems at depth
- South toward the Central Drainage area, bypassing the PCP pumpback system at depth
- Southwest toward the Western Drainage area, bypassing the pumpback system at depth

This groundwater emerges as surface water in the mine drainages south of the MA.

A COPC transport pathway also may exist westward toward the Far West Drainage. However, COPCs have not been detected in groundwater above background levels along this pathway.

1.2.4.3 Air Transport Pathways

Under current conditions, the principal releases of contaminants to air involve dust generation and generation of radon^{222} (radon) gas through radioactive decay of radium^{226}. The highest rates of dust generation are on steep, rocky, sparsely vegetated slopes that are exposed to weathering processes and wind. In the MA, exposed protore piles likely provide most of the contaminants in windblown dust because materials in these piles contain the highest concentrations of COPCs. Forested areas surrounding the MA in the principal (northeast and southwest) downwind areas do not show evidence of air transport of COPCs in dust, and therefore air transport pathways from MA sources to the surrounding areas are judged to be of no practical significance for contaminant migration.

Emanation of radon gas resulting from decay of radium^{226} in protore and waste rock materials causes elevated radon concentrations in air, which may be transported from the MA by wind. The potential also exists for air transport of radon^{222} daughter products, including polonium^{210}

and lead^{210}. Although airborne radon concentrations exceed background values within the MA, airborne radon is present at levels only slightly above background at potentially impacted area (PIA) sampling locations in the principal downwind areas next to the MA and along the West Haul Road.

None of the radionuclides are elevated in the Southwest Downwind Area. Moreover, activity concentrations of the long-lived radon daughter products, polonium^{210} and lead^{210}, in surface and subsurface materials in both of the principal downwind areas from the MA do not show a pattern indicating atmospheric transport of these constituents from the MA into the downwind areas. Therefore, although radon concentrations in air are of concern in the MA and downwind areas, air transport of radon and its daughter products from the MA into these areas is not of practical significance for contaminant migration.

1.2.5 Baseline Risk Assessments

1.2.5.1 Human Health Risk Assessment

A baseline human health risk assessment (HHRA) for the site was conducted to assess whether remedial actions are required to address potential health risks at the site (EPA 2004a). The risk assessment assumed "baseline" conditions of no remedial activities. Specifically, it was assumed the WTP would not be operational, that human exposure to seep water currently being captured would occur, and that there could be future residential development on the site. Although current data were used to quantify risks, the potential for conditions to worsen was considered qualitatively.

The current human use at the site is intermittent hunting and gathering. The Spokane Tribe has expressed a desire to be able to use the site without restrictions in the future and is considering the possibility of constructing a hunting lodge at the site. Because the site is located on reservation land owned by the Tribe and allottees, the focus of the risk assessment was exposures to tribal members. Therefore, exposure factors and pathways representative of tribal subsistence activities were selected as representing the most intensive future use of the land and were based on recommendations from the Tribe. The risk assessment addresses subsistence uses of the site by residents of the MA, residents of the MAA, and non-residents using the site for recreation or subsistence.

In order to estimate health risks for subsistence pathways, data were grouped by media (i.e., soil, sediment, surface water, air, or plants) and by area (MA or MAA). Surface water and sediments in the MAA were further segregated to separate Blue Creek data from data collected from the water and sediments in the East, Central, and Western Drainages and seeps (collectively referred to in the HHRA as "the drainages"). Groundwater data were not separated by area.

At the site, six radionuclides (lead^{210}, radium^{226}, radon^{222}, uranium^{234}, thorium^{228}, and uranium^{238}) and 17 non-radionuclides (total and dissolved metals) were selected as COPCs in at least one medium. Depending on the medium, between three and 15 COPCs were selected. The COPCs were selected for each medium in each area based on whether they exceeded background levels (Section 1.2.3) and, if background concentrations were exceeded, whether concentrations also exceeded a health-based level (non-radionuclides), or contributed significantly to total expected site risks from radionuclides. Groundwater had the most COPCs (15), followed by surface water in the drainages (13) and surface water in the open pits in the MA (11). Soil in the MA (eight COPCs) and sediment in the drainages (nine COPCs) had the largest number of COPCs in surface materials. Relatively few COPCs were selected for the haul roads and the soils adjacent to the haul roads (four and three COPCs, respectively); Blue Creek had six COPCs selected for surface water and three in sediment. Uranium and manganese were the non-radionuclides that were selected in the most media (10 and eight, respectively). Lead^{210} and radium^{226} were the radionuclides selected in eight media, followed by uranium^{238} and uranium^{234} selected in seven media.

Total risks and hazards estimated in the HHRA for residential and non-residential exposures are summarized in Tables 1-1 and 1-2, respectively (EPA 2004a). The contaminants of concern (COCs) are discussed by media below. COCs are defined as "those COPCs and media/exposure points that trigger the need for cleanup (the risk drivers)" (EPA 1998a). The NCP defines acceptable exposure levels to carcinogens and non-carcinogens. For carcinogens, the acceptable exposure level is expressed as a range of cancer risk from 10^{-4} to 10^{-6}. Cleanup action is generally warranted when cancer risk estimates exceed 10^{-4} (1 in 10,000), and cleanup goals are set within the target risk range. For non-carcinogens, if the hazard quotient is below 1, an adverse health effect is not expected. Cancer risks assume any level of the chemical has some risk, whereas for chemicals with non-cancer effects, a "threshold" dose exists. Cancer risk estimates represent the potential for cancer effects by estimating the probability of developing cancer over a lifetime due to site exposures. Non-cancer hazards assume there is a level of chemical intake that is not associated with an adverse health effect even in sensitive individuals.

Risks and hazards were quantitatively evaluated for the following exposure scenarios:

- Residents of the MA who would be exposed to external radiation, airborne radon, and contaminants in soil, groundwater (used for drinking and sweat lodges), plants (growing on the site), and meat (from animals raised on the site, based on a modeled cattle scenario[2])
- Residents of the MAA who would be exposed to external radiation, airborne radon, and contaminants in soil adjacent to the haul road, groundwater or drainages water

[2] Because risks and hazards from the "cattle scenario" were estimated based solely on modeled data, these are not discussed further here. However, modeling did indicate the potential for significant risks from ingestion of livestock that consumed all their food and water from the site.

(used for drinking and sweat lodges), plants (growing on site), and meat (from animals raised on the site, based on a modeled cattle scenario)

- Non-residents who would be exposed to contaminants during use of the pits in the MA for water recreation, through incidental ingestion of pit surface water and sediment during swimming, radon inhalation, and radiation exposure
- Non-residents using the MAA for subsistence purposes that would be exposed to contaminants in soil on and adjacent to the haul roads, in Blue Creek water (drinking water and sweat lodge use), sediment (during plant harvesting activities), and plants, and in meat

A discussion of COCs by media follows.

Surface Water. The HHRA evaluated the following pathways for exposure to COPCs in surface water:

- Ingestion of drinking water (Blue Creek and mine drainages)
- Incidental ingestion during swimming (pit lakes)
- Inhalation of vapor during sweat lodge use (Blue Creek and mine drainages)

The HHRA estimated reasonable maximum exposure (RME) hazards exceeding 1 and lifetime cancer risks exceeding 1 in 10,000 (a 1 x 10^{-4} risk) for all scenarios for surface water. The COCs are uranium and manganese for systemic toxicity and lead^{210}, uranium^{238}, and uranium^{234} for cancer.

- Estimated hazards for ingestion of surface water from the drainages as drinking water range from 48 (adults) to 98 (children)
- Estimated cancer risks for ingestion of surface water as drinking water range from 8 in 10,000 to 1 in 10 (the highest risks are due to ingestion of water from the South Spoils seeps, which are currently collected and treated)
- Estimated hazard for incidental ingestion of surface water during swimming ranges from 9 to 37
- Estimated cancer risk for incidental ingestion of surface water during swimming is 2 in 10,000
- Estimated hazards for inhalation of vapor during sweat lodge use range from 61 to 9,800
- Estimated cancer risks for inhalation of vapor during sweat lodge use range from 2 in 1,000 to 8 in 10

If the risks and hazards due to background levels of the COCs are subtracted from the total risks and hazards for surface water, the incremental risks and hazards, while lower than the values presented above, still exceed acceptable levels by a substantial margin for the majority of COCs. The only surface water COCs that do not have an incremental risk/hazard exceeding acceptable levels are, for the recreational pathway:

- Manganese in pit water
- Uranium^{238} and uranium^{234} in pit water

In Blue Creek and the drainages/seeps, risks and hazards due to background concentrations of some COCs exceeded acceptable levels. However, the risks due to the site were generally an order of magnitude (or more in some cases) greater than background. Therefore, the concentrations of COCs present in Blue Creek and the seeps on the site exceed acceptable levels even if background concentrations are taken into consideration.

Surface Soil and External Radiation. The HHRA evaluated the following pathways for exposure to COPCs in surface soil:

- Ingestion of surface soil (MA and adjacent to haul roads)
- Ingestion of surface soil (haul roads)
- Dermal contact (MA, arsenic and cadmium only)
- External radiation, indoors and outdoors (MA and MAA)

The HHRA estimated RME hazards exceeding 1 and lifetime cancer risks exceeding 1 in 10,000 for all ingestion scenarios for surface soil. The COCs are uranium for systemic toxicity and lead^{210} and radium^{226} for cancer.

Estimated RME lifetime cancer risks due to exposure to external radiation (both indoors and outdoors) exceeded 1 in 10,000. For MA residents, the estimated external radiation risk is 3 in 100, while for MAA residents it is 1 in 100. Non-residential risks for external radiation, based on 2000 hours per year spent on site, also significantly exceeded 1 in 10,000. Estimated RME hazards are less than 1 for the dermal contact pathway.

Background concentrations of external radiation exceed acceptable levels for both indoor and outdoor exposures; however, site concentrations result in health risks an order of magnitude or more above background risks.

Air. The HHRA evaluated risks due to inhalation of airborne radon in indoor and outdoor air. The RME lifetime cancer risks for site residents are 2 in 10 for indoor air and 6 in 1,000 for outdoor air. Recreational visitors spend fewer hours on the site, all outdoors, so their risks are

reduced to 2 in 10,000. Background radon risks also significantly exceed the target cancer risk range, with 8 in 10,000 for outdoor risks and 5 in 1,000 for indoor risks.

Sediment. The HHRA evaluated the following pathways for exposure to COPCs in sediment:

- Ingestion (open pits, Blue Creek, and mine drainages)
- Dermal contact (Blue Creek and mine drainages, selected metals only)

The HHRA estimated RME hazards exceeding 1 resulting from ingestion of sediment in the open pits, mine drainages, and Blue Creek. The COCs are uranium (open pits and mine drainages) and manganese (Blue Creek). The HHRA estimated RME cancer risks exceeding 1 in 10,000 resulting from ingestion of sediment in the open pits and mine drainages. The COCs are lead^{210}, uranium^{238}, uranium^{234}, and radium^{226}. The largest estimated RME hazard is 31 for ingestion of sediment from the mine drainages by children. Estimated hazards in Blue Creek are about an order of magnitude lower than in the open pits and mine drainages and barely exceed target health goals. The largest estimated RME lifetime cancer risk is 1 in 1,000 for ingestion of sediment in the open pits.

Estimated RME hazards are less than 1 for the dermal contact pathway.

Background risks for the four radionuclides that are COCs for sediments did not exceed acceptable levels; however, incremental risks (site risks minus background) either equaled or exceeded the acceptable cancer risk range.

Groundwater. The HHRA evaluated the following pathways for exposure to COPCs in groundwater:

- Ingestion of drinking water
- Inhalation of vapor during sweat lodge use

Concentrations in nine individual wells were evaluated to assess the range of concentrations present in groundwater at the site. All nine wells had risks and hazards in excess of acceptable levels with cancer risks as high as 0.9 (9 in 10) for individual COCs and hazards of 100,000 in the most-impacted well. The COCs are uranium and manganese for systemic toxicity and uranium^{238} and uranium^{234} for cancer. As noted for surface water, the inhalation of vapors during a sweat lodge had higher risks and hazards than use of the water for drinking.

Background risks and hazards exceed acceptable levels, but site risks and hazards were one to three orders of magnitude higher.

Plants. The HHRA evaluated ingestion of terrestrial plant tissue in the MA and ingestion of riparian and aquatic plant tissue in Blue Creek and the mine drainages. Ingestion of plants was

one of three pathways with the highest estimated cancer risks, with risks in 10^{-1} range (the other two pathways with cancer risks this high were radon in indoor air and the sweat lodge scenario using either groundwater or drainages surface water). Non-cancer hazards due to the ingestion of uranium in plants were also very high, with estimated hazard quotients above 10,000. However, the risks and hazards estimated for plant consumption have significant limitations because of the way in which plant data were collected. Individual plants were not sampled, but many different kinds of plants within a defined area were composited prior to being sent to the laboratory for analysis. Therefore, it is not known if there are differences in concentration of the COCs between species. Nor is it known which plant species are the most likely to be consumed, because plant species preferences and utilization patterns were not used to select plant samples. Therefore, the representativeness of the plant data to subsistence activities is uncertain. In addition, all risks and hazards due to plant ingestion were based on concentrations in plant roots, which have higher chemical concentrations than aboveground portions of the plants. If the roots are not the portions of the plant that are consumed, using root concentrations overestimates risks.

Background risks due to plant consumption were also significantly higher than acceptable levels, with risks of 4 in 100 to 6 in 1,000, depending on the chemical. The background plant data were collected in the same manner as the site plant data; therefore, the same limitations apply.

Summary of COCs. For protection of human health, the COCs include:

- Surface water: uranium, manganese, lead^{210}, uranium^{238}, and uranium^{234}
- Surface and subsurface materials: uranium, lead^{210}, and radium^{226}
- Sediment: uranium, manganese, lead^{210}, uranium^{238}, uranium^{234}, and radium^{226}
- Groundwater: uranium, manganese, uranium^{238}, and uranium^{234}
- Air: radon
- Plants: uranium, manganese, lead^{210}, radium^{226}, uranium^{238}, and uranium^{234}

Cancer risks exceeded 1 in 10, considerably above acceptable levels, for the three most "risky" pathways of exposure: 1) inhalation of chemicals in sweat lodge vapor (either from groundwater or from the drainages), 2) inhalation of radon in indoor air, and 3) ingestion of plants. Nearly all the other pathways had cancer risks and non-cancer hazards in excess of acceptable levels. These risks and hazards were estimated assuming continuous, daily exposure over a 70-year lifetime.

Blue Creek had some of the lowest hazards and risks evaluated in this assessment. Sediment exposure hazards marginally exceeded a hazard quotient of 1 for children aged 2 to 6 years, assuming daily exposure and assuming that 100 percent of the soil ingested would be Blue Creek sediment. The adult sediment exposure did not exceed a hazard quotient of 1. Other pathways evaluated for Blue Creek (drinking Blue Creek water, using Blue Creek water in sweat lodges,

and ingesting Blue Creek plants) had higher risks and hazards than sediment exposure. For people using Blue Creek less frequently than daily or obtaining less than 100 percent of their exposure there, the risks would be reduced accordingly, to the point where some of the pathways evaluated could fall within EPA's target risk range and below a non-cancer hazard index of 1.

All the COCs in this assessment occur naturally in the area and were present on the site prior to mining activities. Estimates of the cancer risks associated with exposure to background concentrations of the COCs show cancer risks for the background area that exceed the upper end of EPA's target risk range for most of the pathways evaluated in this assessment. However, because COC levels are significantly higher at the site, risks from background levels of COCs are a small percentage of the risk at Midnite Mine, indicating that mining activities have resulted in significant site-related risks.

1.2.5.2 Ecological Risk Assessment

An ecological risk assessment (EcoRA) was performed for the aquatic, riparian/wetland, and terrestrial components of the Midnite Mine site utilizing the analytical data for samples of soil, surface water, and instream and riparian sediments (EPA 2004b). The EcoRA included both the screening level ecological risk assessment (SLERA) and the baseline ecological risk assessment (BERA), which encompass steps 1 through 7 of the eight-step EPA EcoRA guidance for Superfund (EPA 1997). The eighth step, risk management, follows the completion of the EcoRA process and is not included in the EcoRA. The EcoRA evaluated risks for areas of interest (AOIs) in both the MA and the MAA.

In the SLERA, the metals COPCs were screened by comparing conservative benchmark values to maximum metal concentrations detected at each AOI. The COPCs were not screened based on background. The resulting list of retained metals COPCs was passed to the BERA for further evaluation (EPA 2004b, tables 6 through 12). Total ionizing radiation (TIR) was screened in the SLERA based on the maximum exposures to the mine-related radionuclides. This screening found that the U.S. Department of Energy-recommended dose criterion of 1.0 rad/day was exceeded for aquatic and riparian animals in the MA and MAA and for terrestrial plants and animals in the MA and along the haul roads.

The BERA was performed immediately following completion of the SLERA and consisted of problem formulation, analysis, and risk characterization. The problem formulation identified 22 assessment endpoints encompassing the aquatic, riparian, and terrestrial ecosystems within the MA and MAA. An assessment endpoint is a species, ecological resource, or habitat type that is to be protected, and which is used to guide the development of the study design at the site. Each of the 22 assessment endpoints was evaluated to determine if it was or was not at risk from each of the mine-related metals and radionuclides retained as COPCs in the SLERA.

Assessment endpoints 1, 2, and 3 were used to characterize risk from metal contamination to the aquatic ecosystems in the MA and MAA. Terrestrial ecosystems within the MA and MAA were characterized for risk based on assessment endpoints 4 through 16. Assessment endpoints 4 and 5 were used to characterize risk to the soil microorganisms and plant communities. Assessment endpoints 6 through 16 were used to characterize risk to the mammalian and avian communities. Assessment endpoints 6 through 16, incorporating aquatic, riparian, and terrestrial ecosystems within the project area, were evaluated through the use of food chain models. Four exposure models were used for each avian and/or mammalian receptor species to estimate exposure between abiotic exposure (i.e., surface water, sediments, or soils) and total exposure (i.e., abiotic exposure plus dietary component).

Three assessment endpoints were used to characterize risk to the riparian/wetland habitats within the MAA. Assessment endpoint 17 was used to identify the amphibian community and assessment endpoints 18 and 19 were used to characterize the risk to wetland plant and invertebrate communities. Three assessment endpoints (20, 21, and 22) were identified for characterizing risk from TIR.

COPCs evaluated in the BERA were not screened against background concentrations. Risk was calculated using maximum measured COPC concentrations for a given exposure area. Individual receptors evaluated in the BERA represent a functional group (species in the same feeding group or trophic level).

Conclusions of the BERA are summarized in the following paragraphs.

- Each of the AOIs posed a risk to at least one assessment endpoint. Some AOIs posed a higher risk to a receptor, posed a risk to more receptors, or posed a risk for more contaminants than other AOIs.
- A number of animals (e.g., deer, elk, moose, coyote, bear, and turkey) have been sighted within the MA. The MA is an attraction to wildlife as a source of water and presumably as a source of salts, which are deposited around the water bodies and at the toe of waste rock piles. The utilization by wildlife of the lacustrine habitats within the MA for water and salt results in risk to elk, deer, and other wildlife. Some species of wildlife (e.g., marmot, cliff swallow) that have been reported to inhabit the MA are at significant risk.
- A large number of COPCs were identified within the aquatic habitats of the MA and the MAA. While none of the COPCs could be eliminated, those mine-related COPCs that were more pervasive and detected in higher concentrations stand out (uranium, aluminum, beryllium, cadmium, cobalt, copper, manganese, nickel; lead, selenium, silver, and zinc).
- Metals COPCs present in the MAA drainages are a source of risk to aquatic communities. In addition, the intermittent and/or low flow conditions along with the

poor water quality conditions (e.g. low pH, high sulfate, and high conductivity) are unfavorable for aquatic life within the drainages. The onsite WTP, which operates from spring to fall, serves to significantly reduce the transport of contaminants from the MA to the drainages and Blue Creek. However, the drainages continue to be a conduit for the transport of contaminants from the MA to Blue Creek.

- Aquatic communities in Blue Creek below the confluence of the Eastern Drainage are at risk. The precise source of risk to the aquatic communities in Blue Creek is uncertain, but probably includes both metals COPCs and TIR. Poor water quality (i.e., high sulfate, high hardness, high conductivity) and physical stresses such as variable steam flow also may contribute to conditions unfavorable for aquatic life.
- In general, the greatest predicted risk to terrestrial plants and animals, with the possible exception of the piscivorous animals, was determined to be within the MA.
- The six riparian/wetland AOIs within the MAA pose risk to the amphibian, wetland plant and invertebrate communities based on the high number of COPCs present. Risks to riparian animal populations associated with TIR were found in the Central and Western Drainages, but not in the AOIs of the Eastern Drainage and Blue Creek.

Table 1-1
Summary of Total Risks and Hazards for Residential Exposures[a]

Area/ Exposure Point		Non-Radionuclides				Radionuclides Cancer Risk	Combined Rad and Non-Rad Cancer Risk
		Hazard Index			Cancer Risk		
		Infant	Child	Adult			
Mined Area	Yard Soil	28	22	6	4E-04	3E-03	3E-03
	Groundwater (Drinking Water)[b]	0.087 - 26,749	0.1 - 31,449	0.05 - 15,455	nc	2E-04 - 3E-01	2E-04 - 3E-01
	Groundwater(Sweat Lodge)[b]	--	39 – 38,087	150 - 147,956	2E-04 - 2E-01	2E-03 - 1E+00[e]	2E-03 - 1E+00[e]
	External Radiation (Outdoors)	na	na	na	na	2E-02	2E-02
	External Radiation (Indoors)	na	na	na	na	1E-02	1E-02
	Terrestrial Plants	--	28,686	15,664	5E-02	5E-01	6E-01
	Meat	--	221	109	7E-03	2E-01	2E-01
	Radon (Outdoor Air)	na	na	na	na	6E-03	6E-03
	Radon (Indoor Air)	na	na	na	na	2E-01	2E-01
Total[c]		**28 - 26,777**	**28,969 – 98,466**	**15,928 – 179,189**	**6E-02 –3E-01**	**9E-01 - 1E+00[e]**	**1E+00[e]**
Mining Affected Area	Soil Adjacent to Haul Roads (Ingestion)[d]	5	4	0.9	nc	6E-04	6E-04
	Surface Water in Drainages (Drinking Water)	83	98	48	nc	1E-01	1E-01
	Surface Water in Drainages (Sweat Lodge)	--	2,514	9,767	1E-02	8E-01	8E-01
	Groundwater (Drinking Water)[b]	47 - 3,453	55 – 4,060	27 - 1,995	nc	1E-03 - 2E-02	1E-03 - 2E-02
	Groundwater (Sweat Lodge)[b]	--	2 - 3,941	8 - 15,309	3E-05 - 9E-03	8E-03 - 1E-01	8E-03 - 1E-01
	Sediment in Drainages (Ingestion)[d]	--	31	8	nc	9E-04	9E-04
	External Radiation (Outdoors)	na	na	na	na	5E-03	5E-03
	External Radiation (Indoors)	na	na	na	na	2E-03	2E-03
	Aquatic/Riparian Plants in Drainages	--	40,230-141,653	21,967-77,347	nc	2E-01 – 7E-01	2E-01 – 7E-01
	Meat	--	221	109	7E-03	2E-01	2E-01
	Radon (Outdoor Air)	na	na	na	na	6E-03	6E-03
	Radon (Indoor Air)	na	na	na	na	2E-01	2E-01
Total[c]		**52 - 3,458**	**40,512-149,879**	**22,112-94,761**	**7E-03 - 2E-02**	**1E+00[e]**	**1E+00[e]**

Notes:
Cancer risk notation explanation: 1E-02 equals a cancer risk of 1×10^{-2}
-- Infants were not evaluated for these pathways
na - not applicable
nc - no chemicals were evaluated for carcinogenicity for these pathways.
a. All dietary needs met on site; plants are gathered in the exposure area where the residence is located; protein sources are represented by beef with tissue COPC concentrations modeled from site soil data.
b. Risks from exposure to groundwater reflect a range of concentrations in wells in the Mined Area or Mining Affected Area, as applicable.
c. Totals are presented as a range to reflect the range of COPC concentrations in groundwater and plants
d. Soil adjacent to haul road is used in residential exposures. Haul road soil ingestion is assessed under the non-residential scenario. Risks and hazards for exposure to sediment from the mine drainages address the same pathway and are not included in the total.
e. The probability of contracting cancer cannot be greater than 100%. The maximum cancer risk value reported is 1, although the sum may be greater than 1.

Table 1-2
Summary of Total Risks and Hazards for Non-Residential Exposures

Area	Exposure Point	Non-Radionuclides			Radionuclides Cancer Risk	Combined Rad and Non-Rad Cancer Risk
		Hazard Index		Cancer Risk		
		Child	Adult			
Mined Area Swimmer[a]	Pits (Surface Water)	37	9	na	2E-04	2E-04
	Pits (Sediment)	25	6	na	1E-03	1E-03
	Radon (Outdoor Air)	na	na	na	2E-04	2E-04
	External Radiation (Outdoors)	na	na	na	6E-04	6E-04
Total		**62**	**15**	**--**	**2E-03**	**2E-03**
Mining Affected Area Subsistence User[b]	Haul Roads Soil (Ingestion)[c]	23	6	na	2E-03	2E-03
	Blue Creek Water (Sweat Lodge)	61	236	na	2E-03	2E-03
	Blue Creek Water (Drinking Water)	22	11	na	8E-04	8E-04
	Blue Creek Sediment (Ingestion)[c]	2	0.6	na	na	na
	Blue Creek Plants (Ingestion)[d]	239 – 1,989	130 – 1,086	na	na	na
	Meat (Ingestion)[e]	221	109	7E-03	2E-01	2E-01
Totals[d]		**568 - 2,318**	**493 - 1,449**	**7E-03**	**2E-01**	**2E-01**

Notes:
na - COPCs in area/media not applicable for indicated effect (cancer or non-cancer) for this pathway.
-- The chemical was not evaluated for carcinogenic effects; therefore, there are no values to sum.
a. Assumed that 1 hour per day for 112 days per year is spent at Pits 3 and 4.
b. Subsistence user may be exposed to sediments, surface water and plants in the MAA drainages. See summary risk table for residential exposures.
c. Risks and hazards for sediment ingestion are for the same pathway as haul road soil ingestion. The risks and hazards should not be added together. Shaded values are not included in total.
d. Calculated hazard or risk differs for aquatic and riparian plants in Blue Creek.
e. Risks related to meat consumption are based on modeled COPC uptake from soil values and are the same for all subsistence scenarios.

2.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES AND APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

2.1 INTRODUCTION

The section identifies the RAOs for the site. RAOs provide a general description of the goals of the cleanup. RAOs specify the media and contaminants of concern, potential exposure pathways and receptors, and PRGs. Section 2.2 identifies the media and COCs. Section 2.3 presents the RAOs, and includes identification of general response actions (GRAs). Section 2.4 presents potential ARARs for the cleanup, including ARARs that provide potential cleanup criteria. Section 2.5 presents the PRGs, including a comparison of risk-based criteria, potential criteria contained in ARARs, and background concentrations of COCs in environmental media. Finally, Section 2.6 identifies volumes and areas of contaminated media at the site.

2.2 MEDIA AND CONTAMINANTS OF CONCERN

2.2.1 Media of Concern

Media of concern include four primary and three secondary exposure media. The primary exposure media are:

- Surface and subsurface material including ore, protore, waste rock, haul road material, and soil
- Sediments in surface water bodies such as pits, ponds, and drainages
- Surface water (including seeps) in surface water bodies including pits, ponds, and drainages
- Groundwater

The secondary exposure media are:

- Air (radon only, fugitive dust inhalation is not considered a significant exposure pathway)
- Plant tissue
- Animal tissue

2.2.2 Contaminants of Concern

COCs include chemicals and radionuclides in the MA and other mining-affected areas and are shown in Table 2-1 for protection of human health and in Table 2-2 for protection of ecological

receptors. COCs are defined as the COPCs and media/exposure points that trigger the need for cleanup (the risk drivers) (EPA 1998a).

Essential ecological nutrients and major anions and cations were not evaluated in the EcoRA, except for toxicity associated with sulfate. These constituents also were not considered in the HHRA because they are not associated with toxicity under normal circumstances and/or toxicity information is not available from EPA. EPA guidance states that essential human nutrients such as iron, magnesium, calcium, potassium, and sodium need not be considered in the quantitative risk assessment if they are unlikely to be associated with toxicity at levels encountered at the site (EPA 1998a). For many, quantitative toxicity information is not available from EPA (EPA 1998b). Although a toxicity value exists for iron, the value is based on the upper range of intake rates and is not associated with adverse health effects. Accordingly, iron, magnesium, calcium, potassium, and sodium are not considered COPCs.

2.3 REMEDIAL ACTION OBJECTIVES

This section presents the RAOs for each primary medium of concern at Midnite Mine. The RAOs are medium-specific or area-specific goals for protecting human health and the environment. The RAOs specify COCs and media of concern, exposure routes and receptors, and acceptable COC levels for each exposure route.[3,4]

The acceptable COC levels are the PRGs. The development of PRGs is described in Section 2.5. The final remediation goals will be selected in the ROD.

The preliminary RAOs are presented in Table 2-3, along with GRAs, which are medium-specific actions that may satisfy the RAOs.

Human health remediation goals will be based on the reasonably anticipated future land use at the site. Environmental media in unimpacted areas near the site contain naturally elevated levels of certain metals and radionuclides. Generally, under CERCLA, cleanup levels are not set at concentrations below natural background levels. (See Section 104(3) of CERCLA.)

The reasonably anticipated future uses for the MA are as open space for wildlife, hunting, skiing, and packing, or industrial or commercial uses. Tribal policy is for all reservation lands to be generally available for all uses without any restrictions, with an emphasis on maximizing subsistence, religious and cultural uses consistent with the reservation's status as the Spokane Tribe's permanent homeland. The Tribe has determined to locate a hunting/skiing lodge at the

[3] The ERA identified COCs only for aquatic ecosystems. Further, no acceptable COC levels have been identified at this time. Consequently, RAOs for protection of ecological receptors identify COCs for surface water and sediment only and do not identify acceptable COC levels, except where ARARs are available.
[4] RAOs identify acceptable COC levels and exposure routes because protectiveness can be achieved by reducing exposure (e.g., by capping) as well as by reducing COC levels (e.g., by treatment or removal).

MA. This lodge would include a resident caretaker. Resident Tribal park rangers also would be housed at the site for accessibility to the Blue Creek Basin. According to the Tribe's future use scenario, a portion of the MA would be used for residential use, a portion for temporary residential use, and a portion for livestock associated with the hunting lodge. In establishing any uses, the Tribe, as a government, will need to consider the background concentrations that will remain throughout the MA and the availability of a potable water supply for the immediate future. In establishing any uses at the MA, it must also be recognized that some portions of the MA will contain restrictions on certain uses in order to ensure protection and/or to maintain the effectiveness of the remedy. For instance, when a soil cover is part of the selected remedy, institutional controls (restrictions on motor vehicle use, construction, excavation or drilling) must be included to ensure the long-term effectiveness of containment.

The reasonably anticipated future uses of the MAA include traditional subsistence and residential uses and wildlife management. To ensure protection of human health, some of these uses may need to be restricted following remedy construction, as groundwater, sediment, and surface water RAOs are unlikely to be achieved immediately.

2.4 POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a preliminary identification of potential ARARs and to-be-considered materials for the Midnite Mine Site. The section defines ARARs and to-be-considered materials, and discusses them in terms of environmental medium and subject area headings (for example, surface water quality, waste management, and Native American concerns and cultural resources protection).

2.4.1 Definitions of ARARs and To Be Considered Materials

As defined in the NCP (40 CFR Part 300), "applicable" requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, remedial action, location, or other circumstance at a site.

"Relevant and appropriate" requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not *applicable* to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the site.

In the preamble to the NCP (55 *Federal Register* 8741, March 8, 1990), EPA states that it believes, as a matter of policy, that it is appropriate to treat Indian tribes as states for the purpose of identifying ARARs under CERCLA Section 121(d)(2).

In accordance with this policy, the FS identifies tribal cleanup standards, standards of control and other substantive environmental protection requirements, criteria or limitations promulgated by the Spokane Tribe as potential ARARs and applies the eligibility criteria set forth in Section 121 of CERCLA (i.e., the requirements are promulgated, legally enforceable, generally applicable, more stringent than federal requirements, and identified in a timely manner). State requirements are not applicable, but may be relevant and appropriate.

ARARs are potential or preliminary until finalized by EPA in a ROD for a site. The NCP provides for the waiver of ARARs under certain circumstances (40 CFR 300.415[f][1][i][C]). Because this is a preliminary evaluation of potential ARARs, with remedial alternatives still being developed, any identification of the need for ARAR waivers is preliminary. EPA has consulted with the Tribe on identification of ARARs.

In addition, many federal, state, and tribal environmental and public health programs also have criteria, advisories, guidance, and proposed standards that may provide useful remediation information or recommended procedures. These materials are evaluated, along with ARARs, to establish protective cleanup levels and to help identify remedial action alternatives. If no ARARs address a particular chemical or situation, or if existing ARARs do not provide adequate information, these advisories, criteria, or guidelines are “to be considered” materials available for use in developing CERCLA remedies.

2.4.2 Potential Applicable or Relevant and Appropriate Requirements

Potential ARARs for Midnite Mine are discussed in this subsection under the following categories:

- Surface water quality
- Groundwater quality
- Air quality
- Soil quality
- Waste management
- Native American concerns and cultural resources protection
- Special status species
- Sensitive environments

2.4.2.1 Surface Water Quality

Clean Water Act Section 304—Federal Ambient Water Quality (National Recommended Water Quality Criteria, November 2002, and 67 Federal Register 79091-79095, December 27, 2002). Section 304(a)(1) of the Clean Water Act requires EPA to develop, publish, and revise criteria for water quality accurately reflecting the latest scientific knowledge. CERCLA Section 121(d)(2)(B)(i) provides that, "In determining whether or not any water quality criteria under the Clean Water Act are relevant and appropriate under the circumstances of the release or threatened release, the President shall consider the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which such criteria were developed, and the latest information available."

Therefore, these surface water quality criteria are *potentially relevant and appropriate* to both ambient surface water quality and point source discharges that occur as part of remedial actions. Ambient water quality criteria for nonradiological constituents of potential concern at Midnite Mine are provided in Table 2-4 for protection of human health and freshwater aquatic life. For metals that are hardness dependent, the values shown in the table are calculated based on a hardness of 100 mg/L calcium carbonate ($CaCO_3$). The actual ARAR for these metals is the equation to derive the value rather than the numeric value in the table, which is based on a standard assumption of water hardness.

Spokane Tribe of Indians Surface Water Quality Standards Resolution 2003-259, March 7, 2003. This resolution establishes surface water quality standards for protection of human health and aquatic life for surface waters on tribal lands. The standards were approved by EPA on April 22, 2003 and are *potentially applicable or relevant and appropriate* to remedial actions at the site when the standards are more stringent than federal ambient water quality criteria.

Table 2-4 provides the Spokane Tribe's water quality standards for nonradiological constituents for protection of freshwater aquatic life and for human health (due to risks from ingestion of water or ingestion of water and organisms). Note that some of these standards are based on an assumed hardness value as well, so the potential ARAR is the equation itself. Table 2-5 provides the Tribe's water quality standards for radiological constituents.

Table 2-6 provides standards for protection of human health from direct contact with surface water as a result of spiritual or ceremonial uses. The water quality standards define "primary contact ceremonial and spiritual" water use as activities involving Native American religious, spiritual and cultural practices that may involve primary or secondary contact with water, and immersion and intentional or incidental ingestion of water or steam.

Section 3(2) of the Tribe's water quality standards sets forth circumstances under which natural conditions rather than the numeric criteria assigned by the regulation might constitute water quality criteria. The section, which is *potentially applicable* to the site, states the following:

"Whenever the natural conditions of any specific surface waters of the Reservation are of a lower quality than the criteria assigned to waters typical of that class, the Department may determine that the natural conditions shall constitute the water quality criteria." "Natural conditions" are defined in Section 2 of the standards to mean "surface water quality that was present before human-caused pollution. When assessing natural conditions in the headwaters of a disturbed watershed, it may be necessary to use an appropriate reference site." Since the natural condition of surface waters in the MA and the MAA are of a lower quality than the criteria for most COCs, natural conditions will be the water quality criteria for most COCs.

The antidegradation policy in Section 4 and the Narrative Criteria in Section 5 are potential ARARs; however, as explained in the preamble to the NCP, EPA has considerable latitude in determining how to comply with these general goals.

National Pollutant Discharge Elimination System (NPDES) (40 CFR Part 122). The NPDES program requires that permits be obtained for point-source discharges of pollutants to surface water. The wastewater treatment plant currently operating on site has an NPDES permit from EPA under its Clean Water Act authority, rather than under CERCLA authority. Although permits would not be required for onsite actions under CERCLA, the substantive requirements of the permit program are *potentially applicable* to remedial activities at the site. The primary substantive requirement is that a point source discharge to a surface water body cannot cause an exceedance of water quality standards in the receiving water body, outside an approved mixing zone (if mixing zones are provided for in the regulations).

The substantive requirements of the general stormwater permit program for stormwater discharges associated with industrial and construction activities (40 CFR 122.26) are also *potentially applicable* to remedial actions at Midnite Mine. "Industrial activities" include inactive mining facilities, hazardous waste treatment units, and Resource Conservation and Recovery Act (RCRA) Subtitle D landfills. "Construction activities" include land clearing, grading, and excavation. Substantive requirements state that best management practices (BMPs) must be used, and appropriate monitoring performed, to ensure that stormwater runoff does not cause an exceedance of water quality standards in a receiving surface water body.

2.4.2.2 Groundwater Quality

National Primary Drinking Water Regulations (40 CFR Part 141) promulgated under the Safe Drinking Water Act (SDWA). These regulations protect the quality of public drinking water supplies through regulation of chemical parameters and constituent concentrations as maximum contaminant levels (MCLs) and are *potentially relevant and appropriate* when groundwater is a current or potential source of drinking water. MCLs for the constituents of interest at the site are provided in Table 2-7.

Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR Part 192, Subpart A—Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites, Table 1: Maximum Concentrations of Constituents for Groundwater Protection. These standards were developed under the Uranium Mill Tailings Radiation Control Act (UMTRCA) and are *potentially relevant and appropriate* to remedial actions at the site (they cannot be potentially applicable because Midnite Mine is not a uranium processing site).

Under this regulation, monitoring after disposal must be adequate to determine background groundwater levels of each constituent listed in Table 1 of Subpart A of the regulations that is present in or reasonably derived from residual radioactive materials at the disposal site (Table 2-7). The concentration of a listed constituent in groundwater must not exceed the background level of that constituent in the groundwater; or the respective value given in Table 1 of the regulations if the background level of the constituent is below the value given in the table; or an alternate concentration limit. An alternate concentration limit may be established if, after considering remedial or corrective actions to achieve either background levels or Table 1 levels, it is determined that the constituent will not pose a substantial present or potential hazard to human health and the environment as long as the alternate concentration limit is not exceeded.

The regulation states further that in considering the present or potential hazard to human health and the environment of alternate concentration limits, the following factors must be considered:

- Potential adverse effects on groundwater quality (including physical and chemical constituent characteristics, hydrogeological characteristics of the site and surrounding land, quantity of groundwater and groundwater flow direction, proximity and withdrawal rates of groundwater users, current and future uses of groundwater surrounding the site, existing groundwater quality, potential for human health risks, potential damage to wildlife and crops, and persistence and permanence of potential adverse effects)
- Potential adverse effects on hydraulically connected surface-water quality (including patterns of regional rainfall, site proximity to surface waters, current and future uses of surface waters, existing surface water quality, etc.)

The point of compliance is defined as the location at which the groundwater concentration limits apply. The point of compliance is further described in the regulation as the intersection of a vertical plane with the uppermost aquifer underlying the site, located at the hydraulically downgradient limit of the disposal area plus the area taken up by any liner, dike, or other barrier designed to contain the residual radioactive material.

Spokane Tribe of Indians Hazardous Substances Control Act (HSCA, Resolution 2004-085, December 22, 2003. Section 34-1.11 of HSCA sets forth various ways to determine the

appropriate cleanup standard for surface water, groundwater, soil, and sediment. This includes calculated cleanup standards using tables with standards for individual contaminants (HSCA 34-1.11[a]), a multi-contaminant/multi-pathway formula (HSCA 34-1.11[c]), as well as a recognition that cleanup standards under either of these methodologies do not require cleanup below background levels (HSCA 34-1.11[d]). Since the MA and the MAA have elevated background levels, background is likely to be the default cleanup standard for many COCs. Table 2-7 provides HSCA groundwater cleanup levels. These levels would apply only for sites with a single contaminant, pathway, and exposure medium; however, they serve to indicate the maximum allowable concentration and are included for reference and for comparison to background and risk-based concentrations.

To determine whether the cleanup standard for the individual COCs defaults to background, it is necessary to compare the calculated cleanup standards to background. To the extent that the calculated cleanup standard is not below background, the calculated cleanup standard may be the applicable or relevant and appropriate cleanup standard. To the extent that the calculated cleanup standard is below background, background may be the applicable or relevant and appropriate cleanup standard.

2.4.2.3 Air Quality

National Emission Standards for Hazardous Air Pollutants (NESHAPs) for Uranium Mill Tailings Disposal Sites (40 CFR Part 61, Subpart T). These standards, also found at 40 CFR Part 192, Subpart A, limit radon^{222} flux emissions to ambient air from inactive uranium mill tailings piles to 20 picoCuries per square meter per second. Under 40 CFR Part 192, Subpart A, the standard is an average applied over the entire surface of the disposal site and over at least a one-year period. It applies only to emissions from residual radioactive materials to the atmosphere; i.e., it is in addition to the radon flux that originates in the cover material. These standards are considered *potentially relevant and appropriate* to remedial actions at the site.

Washington Clean Air Act and implementing regulations (WAC 173-400-040(8). This regulation is potentially relevant and appropriate to remedial actions at Midnite Mine. It requires the owner or operator of a source of fugitive dust to take reasonable precautions to prevent the dust from becoming airborne and to maintain and operate the source to minimize emissions.

2.4.2.4 Soil Quality

Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR Part 192, Subpart B—Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials. These standards were developed under the UMTRCA to govern the stabilization, disposal, and control of uranium and thorium mill tailings on land and buildings that are part of a uranium or thorium processing site. Portions of the regulations are *potentially relevant and appropriate* to remedial actions at the site.

The 40 CFR Part 192 Subpart B standards require that remedial actions at designated processing sites be conducted in such a manner as to provide assurance that residual radioactive materials are controlled as follows:

- Concentrations of radium^{226} in land averaged over 100 square meters shall not exceed background by more than:
  - 5 pCi/g averaged over first 15 cm of soil below surface
  - 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below surface.

"Land" as used in the bullet above is defined in 40 CFR 192.11(b) as "any surface or subsurface land that is *not part of a disposal site* and is not covered by an occupiable building" (italics added). Therefore, the potential relevance and appropriateness of these concentrations depends on whether the remedial alternative being evaluated is part of the mined area.

40 CFR Part 192 Subpart E states that the 5 pCi/g and 15 pCi/g standards are suitable for remediation of radium^{228} at certain sites. When used in this way, the standards apply to the combined level of contamination of radium^{226} and radium^{228}. The standards also apply to the combined level of contamination of thorium^{230} and thorium^{232}, parent isotopes of radium^{226} and radium^{228}.

Spokane Tribe of Indians Hazardous Substances Control Act (HSCA) Resolution 2004-085, December 22, 2003. Section 34-1.11 sets forth various ways to determine the appropriate cleanup standard for surface water, groundwater, soil, and sediment. This includes calculated cleanup standards using tables with standards for individual contaminants (HSCA 34-1.11[a]), a multi-contaminant/multi-pathway formula (HSCA 34-1.11[c]), as well as a recognition that cleanup standards under either of these methodologies do not require cleanup below background levels (HSCA 34-1.11[d]). Since the MA and the MAA have elevated background levels, background is likely to be the default cleanup standard for many COCs. Table 2-8 provides HSCA soil cleanup levels.

To determine whether the cleanup standard for the individual COCs defaults to background, it is necessary to compare the calculated cleanup standards to background. To the extent that the calculated cleanup standard is not below background, the calculated cleanup standard may be the applicable or relevant and appropriate cleanup standard. To the extent that the calculated cleanup standard is below background, background may be the applicable or relevant and appropriate cleanup standard.

2.4.2.5 Sediment Quality

Spokane Tribe of Indians Hazardous Substances Control Act (HSCA), Resolution 2004-085, December 22, 2003. Under HSCA, the Tribe has developed sediment cleanup levels for

protection of human health and sediment-dwelling organisms. Section 34-1.11 sets forth various ways to determine the appropriate cleanup standard for environmental media, including sediments. This includes calculated cleanup standards using tables with standards for individual contaminants (HSCA 34-1.11[a]), a multi-contaminant/multi-pathway formula (HSCA 34-1.11[c]), as well as a recognition that cleanup standards under either of these methodologies do not require cleanup below background levels (HSCA 34-1.11[d]). Since the MA and the MAA have elevated background levels, background is likely to be the default cleanup standard for many COCs. Tables 2-8 and 2-9 provide HSCA sediment cleanup levels for protection of human health and protection of bottom-dwelling organisms, respectively.

To determine whether the cleanup standard for the individual COCs defaults to background, it is necessary to compare the calculated cleanup standards to background. To the extent that the calculated cleanup standard is not below background, the calculated cleanup standard may be the applicable or relevant and appropriate cleanup standard. To the extent that the calculated cleanup standard is below background, background may be the applicable or relevant and appropriate cleanup standard.

2.4.2.6 Waste Management

Resource Conservation and Recovery Act Subtitle C regulations; 40 CFR Parts 261, 262, and 264. When RCRA was amended in 1980, Congress exempted certain mining and mineral processing wastes ("Bevill wastes") from Subtitle C (hazardous waste management) requirements. In 40 CFR 261.4(b)(7), EPA defines exempted mining wastes as solid wastes that result from the "extraction, beneficiation, and processing of ores and minerals (including coal, phosphate rock, and *overburden from the mining of uranium ore*), except as provided in 40 CFR 266.112 (italics added).

The extraction and beneficiation wastes that may be located at Midnite Mine are:

- Waste rock, ore, and protore—including overburden, mine development rock, and stockpiled ore and protore
- Mine water—includes all water that collects in surface or underground mines due to groundwater seepage or inflow from surface water or precipitation

While not potentially applicable, elements of Subtitle C regulations are *potentially relevant and appropriate* to ensure the safe management of some solid wastes (e.g., on-site disposal of sludge). Design requirements within RCRA Subtitle C regulations that might be applicable or relevant and appropriate to on-site sludge disposal include selected portions of waste pile design and landfill requirements (40 CFR Part 264, Subparts L and N), and selected portions of the requirements for landfill closure and post-closure (40 CFR Part 264, Subpart G).

Remedial alternatives are still being developed for the Midnite Mine cleanup. If any of the alternatives include provisions for onsite disposal of wastewater treatment sludge, for example, siting restrictions within RCRA Subtitle C would be *potentially relevant and appropriate.* 40 CFR 264.18 prohibits siting in seismically active areas (within 200 feet of a Holocene fault), a 100-year floodplain, and certain geological formations (salt domes, salt bed formations, and underground mines or caves). The site does not include any of these prohibited locations.

Although Bevill wastes are not hazardous wastes, EPA has determined that they are solid wastes, as defined in 40 CFR 261.2 (54 FR 36614, September 1, 1989) and thus are subject to Subtitle D requirements (see below).

Resource Conservation and Recovery Act Subtitle D regulations, Criteria for Classification of Solid Waste Disposal Facilities and Practices, 40 CFR Part 257, Subpart A. These regulations are primarily siting requirements that limit the disposal of solid waste in certain locations. These regulations are *potentially applicable* to management and disposal of material generated by cleanup activity. The regulations require facilities in floodplains to not: restrict the flow of the base flood, not reduce the temporary water storage capacity of the floodplain, result in washout of solid waste; or cause or contribute to the taking of any endangered or threatened species. Facilities must not cause a discharge of pollutants into waters of the U.S. that violates the requirements of the NPDES program and must not contaminate an underground drinking water source beyond the solid waste boundary.

Licensing Requirements for Land Disposal of Radioactive Waste (40 CFR Part 61). These regulations contain performance objectives and technical requirements for Nuclear Regulatory Commission (NRC) licensing of land disposal of radioactive wastes containing byproduct, source and special nuclear material received from other persons. These regulations are *potentially relevant and appropriate* to ensuring the safe land disposal of radioactive waste at Midnite Mine. Subpart C of the regulations provides the following performance objectives for radioactive waste disposal facilities:

- Protection of the general population from releases of radioactivity (an annual dose not to exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ)
- Protection of individuals from inadvertent intrusion
- Protection of individuals during operation
- Stability of the disposal site after closure

Subpart D provides technical requirements for near-surface disposal facilities, including disposal site suitability requirements, disposal site design, disposal site operation and closure, and environmental monitoring.

Spokane Tribe of Indians Hazardous Substances Control Act (HSCA), Resolution 2004-085, December 22, 2003. The disposal of hazardous substances (Section 34-1.12) sections are *potentially applicable or relevant and appropriate* to remedial activities at Midnite Mine.

Section 34-1.12 of HSCA governs the disposal of hazardous substances on the reservation. In the event that the selected remedial action involves the disposal of hazardous substances, some of the requirements of this section of HSCA are potential ARARs. It is EPA's understanding that the requirements of subparagraphs (a) and (b) are potentially applicable to sludge resulting from wastewater treatment, assuming the sludge meets the definition of hazardous substances. If this section of HSCA is determined to be applicable or relevant and appropriate, EPA will work with the Tribe to identify an acceptable location for a sludge disposal facility that meets the substantive requirements of subparagraphs (a) and (b).

2.4.2.7 Native American Concerns and Cultural Resources Protection

Native American Graves Protection and Repatriation Act (NAGPRA), 25 USC§3001 et seq. 43 CFR Part 10. NAGPRA regulations protect Native American graves from desecration through the removal and trafficking of human remains and "cultural items" including funerary and sacred objects. To protect Native American burials and cultural items, the regulations require that if such items are inadvertently discovered during excavation, the excavation must cease and the affiliated tribes must be notified and consulted. This program is *potentially applicable* to ground-disturbing activities such as soil grading and removal.

American Indian Religious Freedom Act, 42 USC§1996 et seq. This statute is *potentially applicable* to soil excavation at the Midnite Mine site. It protects religious, ceremonial, and burial sites and the free practice of religions by Native American groups. If sacred sites are discovered in the course of soil disturbances, work will be stopped and the Spokane Tribe will be contacted.

National Historic Preservation Act (NHPA) regulations, 36 CFR Parts 60, 63, and 800. NHPA regulations require agencies to consider the possible effects on historic sites or structures of actions proposed for federal funding or approval and are *potentially applicable* to remedial actions at Midnite Mine. Historic sites or structures are those included on or eligible for the National Register of Historic Places, generally older than 50 years. If an agency finds a potential adverse effect on historic sites or structures, such agency must evaluate alternatives to "avoid, minimize, or mitigate" the impact, in consultation with the Tribal Historic Preservation Officer (THPO). The NHPA and implementing regulations are applicable to selected remedial activities such as mill building, demolition, and soil excavation, which could disturb historical sites or structures. In consultation with the THPO, unavoidable impacts on historic sites or structures may be mitigated through such means as taking photographs and collecting historical records.

2.4.2.8 Special Status Species

Endangered Species Act (ESA) regulations, 50 CFR Parts 17, 402. The ESA and implementing regulations make it unlawful to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any federally designated threatened or endangered species and/or its habitat. The ESA and implementing regulations are *potentially applicable* to remedial actions that could affect federally designated threatened or endangered species that may be present within the Midnite Mine site area.

The USFWS has indicated that gray wolf (Federal endangered) and the bald eagle, bull trout, Canada lynx, grizzly bear, and Ute ladies'-tresses (all federal threatened) may occur in the vicinity of the project and could be affected by it (USFWS September 5, 2001). Consistent with ESA Section 7, if any federally designated threatened or endangered species are identified in the vicinity of remediation work, and the action may affect such species and/or their habitat, EPA will consult with USFWS to ensure that remedial actions are conducted in a manner to avoid adverse habitat modification and jeopardy to the continued existence of such species.

2.4.2.9 Sensitive Environments

Protection of Floodplains, Executive Order 11988 (40 CFR Part 6, Appendix A). This executive order mandates that response actions taken by Federal agencies must be designed to avoid adverse impacts to floodplains. Specifically, if remediation activities are located within a 100-year floodplain, the activities must be designed to avoid adversely impacting floodplains wherever possible. If remedial activities were to take place in a floodplain, these requirements would be *potentially applicable*.

Protection of Wetlands, Executive Order 11990 (40 CFR Part 6, Appendix A). This executive order mandates that response actions taken by Federal agencies must be designed to avoid long- and short-term impacts to wetlands. If remediation activities are located near/in wetlands, the remediation activities must be designed to avoid adverse impact to the wetlands wherever possible, including minimizing wetlands destruction and preserving wetland values. If remedial activities were to take place in wetlands, these requirements would be *potentially applicable*.

Clean Water Act, Section 404—Dredge or Fill Requirements regulations, 33 CFR Parts 320-330; 40 CFR Part 230. If remedial activities were to result in dredging or filling of waters of the U.S. or associated wetlands, these requirements would be *potentially applicable*. EPA guidelines for discharge of dredged or fill materials in 40 CFR Part 230 specify consideration of alternatives that have less adverse impacts and prohibit discharges that would result in exceedance of surface water quality standards, exceedance of toxic effluent standards, and jeopardy of threatened or endangered species. Special consideration is required for "special aquatic sites," which are defined to include wetlands.

2.4.3 Potential To-Be-Considered Materials

Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-18, Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (August 2, 1997). This directive presents clarifying guidance for establishing cleanup levels protective of human health for radioactive contamination at CERCLA sites. The cleanup levels are expressed as a risk, exposure, or dose level and not as a soil concentration level. The directive clarifies that the appropriate risk range for radionuclides, which are all carcinogens, is 10^{-4} to 10^{-6} (some NRC regulations do not achieve this range and are therefore not sufficiently protective). The directive further states that cancer risk at a site from both radiological and nonradiological contaminants should be summed, and CERCLA decision documents should provide an estimate of the combined risk to individuals presented by all carcinogenic contaminants.

Attachment A to the directive lists likely federal radiation ARARs, including whether they are likely to be applicable or to be relevant and appropriate. Attachment B indicates that EPA has consistently concluded that levels of less than or equal to 15 mrem/yr effective dose equivalent (corresponding to an excess lifetime cancer risk of approximately 3×10^{-4}) are protective and achievable.

Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-25, Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites (February 2, 1998). This directive addresses the use of soil cleanup criteria in 40 CFR Part 192 when setting remediation goals for subsurface soil. The guidance clarifies the extent to which 40 CFR Part 192, Subpart A standards are potentially relevant and appropriate.

2.5 PRELIMINARY REMEDIATION GOALS

This section describes the development of PRGs for surface water, groundwater, surface and stockpiled material, sediment, and air for protection of human health and the environment. PRGs are based on ARARs, site-specific risk-based concentrations (RBCs) that are calculated based on the results of the HHRA and EcoRA, and background levels. PRGs may be different in different areas of the site, based on receptors and exposure pathways present in these areas.

Background levels were developed in the RI for each COC and medium of concern. The selected background level is used to represent the minimum PRG for all affected areas, even if it exceeds a potential ARAR or risk-based concentration. Where a potential ARAR or risk-based criterion is greater than the selected background level, the ARAR or risk-based criterion is used to represent the PRG.

PRGs will apply to exposure pathways determined to be complete and significant by the HHRA. Before implementation of remedial actions, PRGs for protection of ecological receptors will be evaluated for the potential to cause unacceptable adverse impacts to ecosystems or habitats.

2.5.1 Preliminary Remediation Goals for Surface Water

Table 2-10 presents background levels, potential ARARs, risk-based criteria for protection of human health, and ecological benchmarks for surface water. Potential ARARs that may be used as PRGs for surface water include the Spokane Tribe Water Quality Standards, the National Recommended Water Quality Criteria and the federal primary drinking water standards. The Spokane Tribe surface water quality standards include the use of background concentrations as a default standard. This means that the potential ARARs established by the Spokane Tribe surface water quality standards will be the background concentration for most COCs. Similarly, where a risk-based criterion or ecological benchmark is less than the background level, the background level is used to represent the PRG.

2.5.2 Preliminary Remediation Goals for Groundwater

Table 2-11 presents background levels, potential ARARs, risk-based criteria for protection of human health, and surface water protection criteria for groundwater. Potential ARARs that may be used as PRGs for groundwater include the Spokane Tribe groundwater cleanup standards, the federal primary drinking water standards, and groundwater protection standards under UMTRCA. The Spokane Tribe groundwater cleanup standards include the use of background concentrations as a default standard. This means that the potential ARARs established by the Spokane Tribe groundwater cleanup standards will be the background concentration for most COCs. Where ARARs are not available, PRGs will be based on site-specific RBCs. Where an RBC is less than the background level, the background level is used to represent the PRG.

PRGs for groundwater also may be established based on protection of surface water. In this case, the PRGs for groundwater at the location where groundwater discharges to surface water will be based on surface water PRGs.

2.5.3 Preliminary Remediation Goals for Surface and Stockpiled Material and Sediments

Tables 2-12 and 2-13 present background levels, potential ARARs, risk-based criteria for protection of human health, and ecological benchmarks for surface and stockpiled material and sediment, respectively. HSCA is a source of potential ARARs for soil and sediment for protection of human health and for sediment for protection of ecological receptors. Soil cleanup levels under UMTRCA may be used as PRGs for radionuclides in surface and stockpiled material for protection of human health, as described in Section 2.4, where they are more stringent than tribal surface water quality standards or where tribal surface water quality

standards are unavailable. Where ARARs are not available, PRGs are based on site-specific RBCs.

Potential ARARs do not exist for protection of ecological receptors from exposure to surface and stockpiled material and from exposure to some COPCs in sediment. Ecological benchmarks presented in the literature (Efroymson et al. 1997a and 1997b, MacDonald et al. 2000, EVS Environmental Consultants 1998, Environment Canada 2000) were evaluated as potential PRGs in the EcoRA where ARARs were not available.

2.5.4 Preliminary Remediation Goals for Air

For air, the PRG for radon^{222} or its decay products is the EPA standard for radon release rates (20 picoCuries per square meter per second) at inactive uranium mill tailings sites closed under 40 CFR 192.02(b)(1) and 40 CFR 61.222(a).

2.5.5 Summary of Preliminary Remediation Goals

PRGs for the human health risk COCs in surface water, groundwater, surface and stockpiled material, sediment, and air are summarized in Table 2-14. The PRGs are equal to the selected background concentrations for all COCs in all media, except manganese in sediment and the radon release rate for air.

PRGs for the ecological risk drivers in surface water, surface and stockpiled material, and sediment are summarized in Table 2-15. For surface water, the PRGs for copper, lead, nickel, and zinc are equal to the Tribal water quality standards. The PRGs for acute exposure to cadmium and silver are equal to the national recommended water quality criteria, which are more stringent than the Tribal water quality standards. The PRG for chronic exposure to cadmium is equal to the selected background concentration, and the PRG for chronic exposure to silver is equal to the ecological benchmark developed by EPA. The PRGs for beryllium and manganese are equal to ecological benchmarks developed by EPA. The PRGs for aluminum, barium, cobalt, and uranium are equal to the selected background concentrations.

For surface and stockpiled material and sediment, the PRGs are equal to the selected background concentrations for all risk drivers in both media, except chromium in sediment. The PRG for chromium in sediment is equal to the Tribal sediment cleanup standard for protection of sediment-dwelling organisms.

2.6 VOLUMES AND AREAS OF AFFECTED MEDIA

A summary of the estimated volumes and areas of material present in the MA to which general response actions might be applied (including ore, protore, and waste rock) is presented in Table 2-16.

A summary of the measured volumes of contaminated seep and surface water treated in the water treatment plant is presented in Table 2-17.

Table 2-1
Contaminants of Concern for Protection of Human Health

Contaminant	Primary Medium of Concern				
	Surface and Stockpiled Material	**Sediment**	**Surface Water**	**Groundwater**	**Air**
Uranium (total)	X	X	X	X	
Manganese		X	X	X	
$Lead^{210}$	X	X	X		
$Radium^{226}$	X	X			
$Uranium^{238}$		X	X	X	
$Uranium^{234}$		X	X	X	
$Radon^{222}$					X

X indicates contaminant is a COC for that medium

Table 2-2
Risk Drivers for Protection of Ecological Receptors

Contaminant	Medium of Concern		
	Surface Water	Sediment	Surface and Stockpiled Material
Aluminum	X		
Barium	X		
Beryllium	X		
Cadmium	X		X
Chromium		X	
Cobalt	X		
Copper	X		
Lead	X		X
Manganese	X	X	
Nickel	X		
Selenium		X	
Silver	X		
Uranium	X	X	X
Vanadium		X	
Zinc	X		

X indicates contaminant is a risk driver for that medium

Table 2-3
Remedial Action Objectives and General Response Actions

Media of Concern	Remedial Action Objectives[a,b,c]	Preliminary General Response Actions[d]
Surface and stockpiled material and sediments[e]	Reduce exposure of humans and ecological receptor populations to COCs in mining-affected surface and stockpiled material and sediments to levels that comply with ARARs and do not result in unacceptable risks.[e] Reduce exposure of individuals of special-status biota protected under the ESA and the Migratory Bird Treaty Act to COCs in surface material and sediments within habitat areas supportive of these biota that result in unacceptable risks. Reduce loadings of COCs from surface and stockpiled materials and sediments to surface water and groundwater so that loadings do not cause exceedances of potential surface water and groundwater quality ARARs or result in unacceptable risks. Reduce environmental transport of mining-affected surface material from the MA to areas outside of the MA. Prevent future removal of mining-affected surface and stockpiled material.	Institutional and Access Controls Containment/Consolidation - Segregation - Consolidation - Regrading and revegetation - Cover system - Bioengineered stream channel and banks Removal and Relocation - Onsite disposal in open pits - Onsite disposal in aboveground cell - Offsite disposal Ex-Situ Treatment - Stabilization - Solidification In-Situ Treatment - Solidification Beneficiation/Processing
Surface Water[f]	Reduce exposure of humans and ecological receptor populations to COCs in surface water to levels that comply with ARARs and do not result in unacceptable risks. Reduce exposure of individuals of special-status biota protected under the ESA and the Migratory Bird Treaty Act to COCs in surface water within habitat areas supportive of these biota that result in unacceptable risks. Reduce infiltration of surface water into acid mine drainage (AMD)-generating materials and reduce erosion and environmental transport of mining-affected surface materials by surface water. Reduce loadings of COPCs from surface water to groundwater so that loadings do not cause exceedances of potential groundwater quality ARARs or result in unacceptable risks.	Institutional and Access Controls Containment - Surface water controls Removal - Dewater open pits - Backfill pits Collection and Treatment In-Situ Treatment

Table 2-3 (Continued)
Remedial Action Objectives and General Response Actions

Media of Concern	Remedial Action Objectives[a,b,c]	Preliminary General Response Actions[d]
Groundwater	Reduce exposure of humans to COCs in groundwater to levels that comply with ARARs and do not result in unacceptable risks. Reduce loadings of COCs from groundwater to surface water so that loadings do not cause exceedances of potential surface water quality ARARs or result in unacceptable risks.	Institutional and Access Controls Containment/Source Control - Hydraulic barrier - Physical barrier - Permeable reactive barrier Collection and Treatment In-Situ Treatment
Air	Reduce exposure of humans to radon^{222} or its decay products by limiting the average radon^{222} release rate from radioactive materials to levels that comply with ARARs and do not result in unacceptable risk.	Institutional and Access Controls Containment
Plants	Reduce exposure of humans and animals to COCs in plant material at levels that result in unacceptable risks.	Institutional and Access Controls Surface and Stockpiled Material, Sediment, Surface Water, and Groundwater GRAs

Notes
a. Remediation goals will not be less than background levels established in the ROD.
b. Remedial actions that would cause unacceptable adverse impacts to ecosystems or habitats would not be implemented.
c. Unacceptable risks are defined as excess cancer risks exceeding 10^{-4} to 10^{-6} for carcinogenic COCs and excess hazard quotients exceeding 1 for non-carcinogenic COCs.
d. Surface and stockpiled material includes soil, ore, protore, waste rock, overburden, including these materials used in haul road construction. Sediments include sediments in pits, ponds, creeks, and drainages.
e. Surface water includes seeps, pit water, ponds, creeks, and drainages.
f. General response actions for all media include no action. Institutional controls for all media include use restrictions, information programs, and/or monitoring.

Table 2-4
Surface Water Quality Standards for Protection of Human Health and Aquatic Life – Nonradiological Constituents

Constituent[a]	Protection of Aquatic Life[b] (µg/L)				Protection of Human Health[c] (µg/L)			
	Acute		Chronic		Consumption of Water and Organisms		Consumption of Organisms Only	
	Spokane Tribe[d]	USEPA[e]	Spokane Tribe[d]	USEPA[e]	Spokane Tribe[d]	USEPA[e]	Spokane Tribe[d]	USEPA[e]
Aluminum (pH 6.5-9.0)	750	750	87	87	--	--	--	--
Antimony	--	--	--	--	13.4	5.6	324	640
Arsenic	340[m]	340[n]	150[m]	150[n]	0.0069[l]	0.018 [n,l,o]	0.0105[l]	0.14 [n,l,o]
Barium	--	--	--	--	1,000	1,000	--	--
Cadmium	3.7[g]	2.0[g]	1.03[g]	0.25[g]	--	--	--	--
Chromium III	549[g]	570[g]	74.1[g]	74[g]	--	--	--	--
Chromium VI	15	16	10	11	--	--	--	--
Copper	13.4[g]	13[g]	8.96[g]	9.0[g]	119	1,300 [j]	--	--
Iron	--	--	1,000	--	300	300	--	--
Lead	64.6[g]	65[g]	2.52[g]	2.5[g]	--	--	--	--
Manganese	--	--	--	--	--	--	--	100
Mercury [f]	1.4	1.4	0.012	0.77	0.011	--	0.011	--
Nickel	468[g]	470[g]	52[g]	52[g]	231	610	345	4,600
Selenium	20	--	5.0	5.0[i]	145	170	845	4,200
Silver	3.45[g]	3.2[g]	--	--	--	--	--	--
Sulfide - H_2S	--	--	2.0	--		--	--	--
Thallium	--	--	--	--	0.388	0.24[k]	0.463	0.47[k]
Zinc	114[g]	120[g]	105[g]	120[g]	3,470	7,400 [j]	5,180	26,000 [j]

Notes
[a]Constituents from Quality Assurance Project Plan for the Midnite Mine (U.S. EPA 2000a).
[b] All Spokane Tribe criteria listed for protection of aquatic life are for total recoverable metals except cadmium, chromium, copper, lead, nickel, silver, and zinc, which are measured as dissolved metals. All USEPA criteria listed for protection of aquatic life are for dissolved metals, except for aluminum and selenium, which are for total recoverable metals.
[c] All criteria listed for protection of human health are for total recoverable metals.
[d]Spokane Tribe of Indians Surface Water Quality Standards, Resolution 2003-259 (March 7, 2003)
[e]National Recommended Water Quality Criteria: 2005, EPA Office of Water, except where noted. Available at <http://epa.gov/waterscience/criteria/wa.criteria.html> Accessed September 2005.
[f] Spokane Tribe mercury chronic criterion is based on human toxicity from bioaccumulation of mercury in fish tissue and is not based on toxicity to aquatic organisms. If ambient concentration exceeds 0.012 ug/L more than once during 3-year period the edible portion of aquatic species of concern must be analyzed to determine whether the concentration of methyl mercury exceeds the FDA action level of 1.0 mg/kg.
[g] Criterion is hardness dependent; calculated at hardness of 100 mg/L as $CaCO_3$. Actual ARAR is equation used to derive this value.
[h] Criteria in the matrix based on carcinogenicity (10^{-6} risk).
[i] This recommended water quality criterion refers to the inorganic form only.
[j] The organoleptic effect criterion is more stringent than the value for priority toxic pollutants.
[k]Human health criterion revised by EPA December 27, 2002 (67 *Federal Register* 79094).
[l]Expressed in terms of total recoverable metal in the water column-- can be converted to a dissolved metal concentration.
[m]In trivalent form only
[n]Derived from data for trivalent arsenic, but is applied here to total arsenic, which may imply that trivalent arsenic and hexavalent arsenic are equally toxic to aquatic life and that their toxicities are additive.
[o]EPA is currently assessing the human health criteria for arsenic.

Table 2-5
Surface Water Quality Standards for Radiological Constituents

Constituent/Parameter	Unit	Surface Water Quality Standard[a]
Gross alpha particle activity		"Shall not exceed concentration from naturally occurring materials"
$Radium^{226}$ + $Radium^{228}$ (combined dissolved)	pCi/L	5
Gross alpha particle concentrations[b]	pCi/L	15
Gross beta radiation concentration	pCi/L	50
Beta particle + photon radioactivity	millirem/yr	4[c]
$Protactinium^{234}$	pCi/L	30
$Lead^{206}$ [d]	µg/L	5.0
$Lead^{207}$ [d]	µg/L	5.0
$Lead^{208}$ [d]	µg/L	5.0
$Lead^{210}$	pCi/L	0.01
$Lead^{212}$	pCi/L	2.0
$Polonium^{210}$	pCi/L	0.04
$Radium^{226}$	pCi/L	0.06
$Thorium^{232}$	pCi/L	0.03
$Thorium^{234}$	pCi/L	5.0
$Uranium^{234}$	pCi/L	0.30
$Uranium^{235}$	pCi/L	0.30
$Uranium^{238}$	pCi/L	0.30
Uranium (natural)	pCi/L	0.30

[a] Spokane Tribe of Indians Surface Water Quality Standards, Resolution 2003-259 (March 7, 2003).
[b] Including $Radium^{226}$ but excluding radon and uranium.
[c] Annual dose equivalent to the total body or any internal organ.
[d] $Lead^{206}$, $lead^{207}$, and $lead^{208}$ are the stable end members of the $uranium^{238}$, $uranium^{235}$, and $thorium^{232}$ decay chains and therefore are not radioactive. The sum of $lead^{206}$, $lead^{207}$, and $lead^{208}$ shall not exceed 5 µg/L.
pCi/L = picoCuries per liter
µg/L = micrograms per liter

Table 2-6
Surface Water Quality Standards for Protection of Human Health for Exposure from Primary Contact Ceremonial and Spiritual Uses

Constituent/Parameter	Concentration[a] (µg/L unless otherwise indicated)
Aluminum	50
Antimony	6
Arsenic	50
Barium	1,000
Beryllium	4
Cadmium	5
Chloride	250,000
Chromium (total)	100
Copper	1,000
Fluoride	2,000
Iron	300
Manganese	50
Mercury	2
Nitrate (as N)	10,000
Nitrite (as N)	1,000
Total Nitrate + Nitrite (as N)	10,000
pH	6.5-8.5 std. units
Selenium	50
Silver	100
Sulfate	250,000
Thallium	2
Total dissolved solids (TDS)	500,000
Zinc	5,000

[a] Spokane Tribe of Indians Surface Water Quality Standards Resolution 2003-259 (March 7, 2003).
µg/L = micrograms per liter
pCi/L = picoCuries per liter

Table 2-7
Groundwater Quality Standards

Chemical Constituent	Units	Tribal Hazardous Substances Control Act	Primary Maximum Contaminant Levels (MCLs)[a] 40 CFR Part 141	Maximum Groundwater Protection Values[b] 40 CFR Part 192
Aluminum	µg/L	23,300	--	--
Antimony	µg/L	9.33	6	--
Arsenic	µg/L	0.0156	10	50
Barium	µg/L	1,630	2,000	1,000
Beryllium	µg/L	46.7	4	--
Cadmium	µg/L	11.7	5	10
Chromium (total)	µg/L	117	100	50
Cobalt	µg/L	1,400	--	--
Copper	µg/L	867	1,300[c]	--
Iron	µg/L	7,000	--	--
Lead	µg/L	--	15[c]	50
Manganese	µg/L	1,090	--	--
Mercury	µg/L	7	2	2
Molybdenum	µg/L	117	--	100
Nickel	µg/L	467	--	--
Selenium	µg/L	117	50	10
Silver	µg/L	117	--	50
Thallium	µg/L	1.87	2	--
Uranium	µg/L	4.67	30	--
Vanadium	µg/L	163	--	--
Zinc	µg/L	7,000	--	--
Lead^{210} [f]	pCi/L	0.0064	--	--
Radium^{226} [f]	pCi/L	0.0442	--	--
Radium^{228} [f]	pCi/L	0.0195	--	--
Combined Radium^{226} and Radium^{228}	pCi/L	--	--	5
Thorium^{228} [f]	pCi/L	0.0805	--	--
Uranium^{235} [f]	pCi/L	0.259	--	--
Uranium^{238} [f]	pCi/L	0.232	--	--
Combined Uranium^{234} and Uranium^{238}	pCi/L	--	--	30[d]
Alpha particles	pCi/L	--	--	15[e]
Beta particles and photon emitters	millirem/ year	--	--	--

[a] MCLs listed at the following EPA website, accessed February 10, 2003: http://www.epa.gov/safewater/mcl.html.
[b] Maximum Concentration of Constituents for Groundwater Protection, listed in 40 CFR Part 192, Subpart A, Table 1.
[c] Action levels rather than MCLs.
[d] Combined uranium^{234} and uranium^{238}. Where secular equilibrium obtains, this criterion will be satisfied by a concentration of 0.044 milligrams per liter (or 44 ug/L). For conditions of other than secular equilibrium, a corresponding value may be derived and applied, based on the measured site-specific ratio of the two isotopes of uranium.
[e] MCL excludes contribution from radon and uranium
[f] Cleanup levels are calculated for the parent and decay products.

Table 2-8
Tribal Soil and Sediment Cleanup Standards for Protection of Human Health

Chemical Constituent	Units	Tribal Hazardous Substances Control Act
Aluminum	mg/kg	40,000
Antimony	mg/kg	16
Arsenic	mg/kg	0.117
Barium	mg/kg	2,800
Beryllium	mg/kg	80
Cadmium	mg/kg	20
Chromium (total)	mg/kg	200
Cobalt	mg/kg	2,400
Copper	mg/kg	1,490
Iron	mg/kg	12,000
Lead	mg/kg	--
Manganese	mg/kg	1,870
Mercury	mg/kg	12
Molybdenum	mg/kg	200
Nickel	mg/kg	800
Selenium	mg/kg	200
Silver	mg/kg	200
Thallium	mg/kg	3.2
Uranium	mg/kg	8
Vanadium	mg/kg	280
Zinc	mg/kg	12,000
$Lead^{210}$ [a]	pCi/g	0.0368
$Radium^{226}$ [a]	pCi/g	0.134
$Radium^{228}$ [a]	pCi/g	0.0427
$Thorium^{228}$ [a]	pCi/g	0.121
$Uranium^{235}$ [a]	pCi/g	0.60
$Uranium^{238}$ [a]	pCi/g	0.466

[a]Cleanup levels are calculated for the parent and decay products.

Table 2-9
Tribal Sediment Cleanup Standards for Protection of Sediment-Dwelling Organisms

Chemical Constituent	Units	Tribal Hazardous Substances Control Act
Arsenic	mg/kg	9.79
Cadmium	mg/kg	0.99
Chromium (total)	mg/kg	43.4
Copper	mg/kg	31.6
Lead	mg/kg	35.8
Mercury	mg/kg	0.18
Nickel	mg/kg	22.7
Zinc	mg/kg	121

Table 2-10
Potential PRGs and Ecological Benchmarks for Surface Water

					Human Health Values										Ecological Values		
					Potential ARARs				Risk-Based Concentrations[m]						Potential ARARs		
									Ingestion			Ingestion + Sweat lodge					
Constituent	Human Health COPC	Preliminary Ecological COPC[a]	Units	Background 95% UTL[g]	Tribal WQS Consumption of Water + Org.[c]	Tribal WQS Ceremonial and Spiritual Use[c]	SDWA Drinking Water Standards	CWA Consump of Water + Org.[e]	HQ=1	Risk =10E-4	Risk =10E-6	HQ=1	Risk =10E-4	Risk =10E-6	Tribal Protection of Aquatic Org.[c,d]	CWA Protection of Aquatic Org.[d,e]	Ecological Benchmark[b]
Radionuclides																	
Gross Alpha			pCi/L	**52**	15	--	15	--	--	--	--	--	--	--	--	--	--
Lead 210	x		pCi/L	**2.5**	0.01	--	--	--	--	0.8	0.008	--	0.46	0.005	--	--	--
Polonium 210			pCi/L	**6.2**	2.0	--	--	--	--	3	0.03	--	0.93	0.009	--	--	--
Radium 226		x	pCi/L	**1.8**	0.06	--	5	--	--	3	0.03	--	0.88	0.009	--	--	--
Radium 228		x	pCi/L	**2.6**	--	--	5	--	--	1	0.01	--	0.72	0.007	--	--	--
Radon 222, Calculated	x		pCi/L	**3,373**	--	--	--	--	--	75	0.75	--	72.04	0.720	--	--	--
Thorium 227			pCi/L	**0.29**	--	--	--	--	--	21	0.21	--	0.44	0.004	--	--	--
Thorium 228			pCi/L	**3.3**	--	--	--	--	--	3	0.03	--	0.11	0.001	--	--	--
Thorium 230			pCi/L	**3.6**	--	--	--	--	--	11	0.11	--	0.52	0.005	--	--	--
Thorium 232		x	pCi/L	**1.5**	0.03	--	--	--	--	10	0.10	--	0.35	0.003	--	--	--
Uranium 234	x	x	pCi/L	**8.8**	5.0	--	--	--	--	14	0.14	--	1.25	0.013	--	--	--
Uranium 235		x	pCi/L	0.28	**0.30**	--	--	--	--	14	0.14	--	1.40	0.014	--	--	--
Uranium 238	x	x	pCi/L	**7.6**	0.30	--	--	--	--	11	0.11	--	1.46	0.015	--	--	--
Total Inorganics																	
Aluminum	x	x	ug/l	**9,073**	--	50	--	--	8,600	--	--	1,298	--	--	87[i]	87[i]	--
Antimony	x		ug/l	1.6	13.4	6	6	**5.6**	3	--	--	3	--	--	--	--	30
Arsenic			ug/l	**18**	0.0069	50	10	0.018[l]	3	1	0.01	3	0.7	0.007	150[j]	--	--
Barium		x	ug/l	165	**1,000**	**1,000**	2,000	1,000	602	--	--	124	--	--	--	--	3.9
Beryllium	x	x	ug/l	0.23	--	**4**	**4**	--	17	--	--	5	4	0.04	--	--	0.53
Cadmium	x	x	ug/l	0.50	--	5	5	--	4	--	--	**4**	5	0.05	--	--	--
Chromium		x	ug/l	4.9	--	**100**	**100**	--	26	--	--	2	0.1	0.001	--	--	--
Cobalt	x	x	ug/l	**3.0**	--	--	--	--	172	--	--	6	3	0.03	--	--	3
Copper		x	ug/l	9.6	**119**	1,000	1,300	1,300	344	--	--	344	--	--	--	--	--
Iron		x	ug/l	**5,784**	300	300	--	300	2,580	--	--	2,580	--	--	1,000	--	--
Lead	x	x	ug/l	4.7	--	--	**15**	--	--	--	--	--	--	--	--	--	--
Manganese	x	x	ug/l	**72**	--	50	--	--	401	--	--	15	--	--	--	--	80
Mercury		x	ug/l	**0.1**	0.011	2	2	--	3	--	--	3	--	--	0.012[h]	--	--
Molybdenum			ug/l	12	--	--	--	--	**43**	--	--	**43**	--	--	--	--	--
Nickel	x	x	ug/l	4.9	**231**	--	--	610	172	--	--	172	--	--	--	--	--
Selenium		x	ug/l	0.59	145	**50**	**50**	170	43	--	--	43	--	--	5.0	--	--
Silver		x	ug/l	**0.8**	--	100	--	--	43	--	--	43	--	--	--	--	0.08
Thallium		x	ug/l	**1.1**	0.388	2	2	0.24[k]	0.6	--	--	1	--	--	--	--	4
Uranium	x	x	ug/l	**20**	--	--	30	--	2	--	--	2	--	--	--	--	2.6
Vanadium		x	ug/l	7.8	--	--	--	--	**60**	--	--	**60**	--	--	--	--	19
Zinc	x	x	ug/l	10	**3,470**	5,000	--	7,400	2,580	--	--	2,580	--	--	--	--	--

Constituent	Human Health COPC	Preliminary Ecological COPC[a]	Units	Background 95% UTL[g]	Human Health Values										Ecological Values		
					Potential ARARs				Risk-Based Concentrations[m]						Potential ARARs		
									Ingestion			Ingestion + Sweat lodge					
					Tribal WQS Consumption of Water + Org.[c]	Tribal WQS Ceremonial and Spiritual Use[c]	SDWA Drinking Water Standards	CWA Consump of Water + Org.[e]	HQ=1	Risk =10E-4	Risk =10E-6	HQ=1	Risk =10E-4	Risk =10E-6	Tribal Protection of Aquatic Org.[c,d]	CWA Protection of Aquatic Org.[d,e]	Ecological Benchmark[b]
Dissolved Inorganics																	--
Aluminum	x	x	ug/l	1,241	--	--	--	--	8,600	--	--	**1,298**	--	--	--	--	--
Antimony	x	x	ug/l	2.3	--	--	--	--	**3**	--	--	**3**	--	--	--	--	30
Arsenic			ug/l	**13**	--	--	--	--	3	1	0.01	3	0.7	0.007	--	150	
Barium		x	ug/l	**113**	--	--	--	--	602	--	--	124	--	--	--	--	3.9
Beryllium		x	ug/l	**0.1**	--	--	--	--	17	--	--	5	4	0.04	--	--	0.53
Cadmium	x	x	ug/l	**0.5**	--	--	--	--	4	--	--	4	5	0.05	1.03[f]	0.25[f]	--
Chromium		x	ug/l	**0.63**	--	--	--	--	--	--	--	2	0.1	0.001	--	--	--
Chromium III			ug/l	--	--	--	--	--	--	--	--	--	--	--	74.1[f]	74[f]	--
Chromium VI	x		ug/l	--	--	--	--	--	**26**	--	--	--	--	--	10	11	--
Cobalt	x	x	ug/l	**1.4**	--	--	--	--	172	--	--	6	3	0.03	--	--	3
Copper	x	x	ug/l	2.6	--	--	--	--	**344**	--	--	**344**	--	--	8.96[f]	9.0[f]	--
Iron		x	ug/l	**5,105**	--	--	--	--	2,580	--	--	2,580	--	--	--	--	--
Lead	x	x	ug/l	1.2	--	--	--	--	--	--	--	--	--	--	2.52[f]	2.5[f]	--
Manganese	x	x	ug/l	**49**	--	--	--	--	401	--	--	15	--	--	--	--	80
Mercury		x	ug/l	--	--	--	--	--	**3**	--	--	**3**	--	--	--	0.77	--
Molybdenum			ug/l	--	--	--	--	--	**43**	--	--	**43**	--	--	--	--	--
Nickel	x	x	ug/l	1.4	--	--	--	--	**172**	--	--	**172**	--	--	52[f]	52[f]	--
Selenium			ug/l	0.33	--	--	--	--	**43**	--	--	**43**	--	--	--	--	--
Silver		x	ug/l	**0.9**	--	--	--	--	43	--	--	43	--	--	3.45[f]	3.2[f]	0.08
Thallium		x	ug/l	7,173	--	--	--	--	0.6	--	--	1	--	--	--	--	4
Vanadium		x	ug/l	2.4	--	--	--	--	**60**	--	--	**60**	--	--	--	--	19
Zinc		x	ug/l	14	--	--	--	--	**2,580**	--	--	**2,580**	--	--	105[f]	120[f]	--

identifies contaminants of concern (COCs) as determined in the human health risk assessment

Bolded value identifies the PRG for protection of human health. Where an ARAR concentration is available, the PRG is the higher of the ARAR concentration and background. Where no ARAR concentration is available, the PRG is the higher of the RBC and background. (Note: for risk-based concentrations based on cancer risk, only values corresponding to a 10^{-6} cancer risk were considered.)

-- indicates no value is available

[a]Preliminary ecological COPCs for radionuclides are for combined surface water and sediment.

[b]Freshwater benchmarks derived from EPA regions. Benchmarks are presented for constituents that do not have a chronic Tribal water quality standard or national recommended water quality criterion. Note: ecological benchmarks are not based on site-specific conditions and do not represent PRGs.

[c]Spokane Tribe of Indians Surface Water Quality Standards, Resolution 2001-144 (February 13, 2001).

[d]Criteria for chronic exposure

[e]National Recommended Water Quality Criteria: 2002, EPA Office of Water, November 2002, except where noted.

[f] Criterion is hardness dependent; calculated at hardness of 100 mg/L as $CaCO_3$. Actual ARAR is equation used to derive this value. A hardness of 30 mg/L as CaCO3 was used in the ecological COPC screening.

[g] 95% upper tolerance limit

[h] Spokane Tribe mercury chronic criterion is based on human toxicity from bioaccumulation of mercury in fish tissue and is not based on toxicity to aquatic organisms. If ambient concentration exceeds 0.012 ug/L more than once during 3-year period the edible portion of aquatic species of concern must be analyzed to determine whether the concentration of methyl mercury exceeds the FDA action level of 1.0 mg/kg.

[i] Criteria is pH dependent. This value is based on pH of 6.5-9.0.

[j]Trivalent form only

[k] Human health criterion revised by EPA December 27, 2002 (67 *Federal Register* 79094)

[l] This recommended water quality criterion refers to the inorganic form only, and is based on carcinogenic risk of 10^{-6}. EPA is currently assessing the human health criteria for arsenic.

[m]Risk-based concentrations are based on the following tribal-specific exposure parameters:
Exposure duration = 70 years
Ingestion rate = 4 liter/day (adult) and 2 liter/day (child)
Vapor inhalation rate (sweat lodge) = 0.83 m^3/day (adult) and 0.42 m^3/day (child)

Table 2-11
Potential PRGs for Groundwater

Constituent	Human Health COPC	Preliminary Ecological COPC[d]	Units	Background 95% UTL[h]	Potential ARARs			Risk-Based Concentrations[l]						Surface Water Protection	
								Ingestion			Ingestion + Sweat lodge				
					SDWA Drinking Water Standard	UMTRCA GW Protection[b]	Tribal HSCA[k]	HQ=1	Risk =10E-4	Risk =10E-6	HQ=1	Risk =10E-4	Risk =10E-6	Human Health[a]	Ecological[c]
Radionuclides															
Gross Alpha	x		pCi/L	**189**	15	--		--	--	--	--	--	--	--	--
Lead 210			pCi/L	**70**	--	--	0.0064	--	0.8	0.008	--	0.46	0.005	--	--
Polonium 210			pCi/L	**28**	--	--	--	--	3	0.03	--	0.93	0.009	--	--
Radium 226	x	x	pCi/L	**12**	5	5[e]	0.0442	--	3	0.03	--	0.88	0.009	--	--
Radium 228		x	pCi/L	**13**	5	5[e]	0.0195	--	1	0.01	--	0.72	0.007	--	--
Radon 222, Calculated			pCi/L	**89,155**	--	--	--	--	75	0.75	--	72.04	0.720	--	--
Thorium 227			pCi/L	**0.84**	--	--	--	--	21	0.21	--	0.44	0.004	--	--
Thorium 228			pCi/L	**2.5**	--	--	0.0805	--	3	0.03	--	0.11	0.001	--	--
Thorium 230			pCi/L	**6.4**	--	--	--	--	11	0.11	--	0.52	0.005	--	--
Thorium 232		x	pCi/L	**3.4**	--	--	--	--	10	0.10	--	0.35	0.003	--	--
Uranium 234	x	x	pCi/L	**37**	--	30[f]	--	--	14	0.14	--	1.25	0.013	--	--
Uranium 235		x	pCi/L	**2.3**	--	--	0.259	--	14	0.14	--	1.40	0.014	--	--
Uranium 238	x	x	pCi/L	**35**	--	30[f]	0.232	--	11	0.11	--	1.46	0.015	--	--
Total Inorganics															
Aluminum		x	ug/l	**35,272**	--	--	23,300	8,600	--	--	1298	--	--	--	87[i]
Antimony			ug/l	**7.1**	6	--	9.33	3	--	--	3	--	--	13.4	--
Arsenic			ug/l	**78**	10	50	0.0156	3	1	0.01	3	0.7	0.007	0.0069	150
Barium			ug/l	127	2,000	**1,000**	1,630	602	--	--	124	--	--	116	--
Beryllium	x		ug/l	2.7	**4**	--	47	17	--	--	5	4	0.04	--	--
Cadmium	x	x	ug/l	0.52	**5**	10	11.7	4	--	--	4	5	0.05	--	--
Chromium[j]			ug/l	74	100	**50**	117	26	--	--	2	0.1	0.001	--	--
Cobalt	x		ug/l	17	--	--	**1,400**	172	--	--	6	3	0.03	--	--
Copper		x	ug/l	80	1,300	--	**867**	344	--	--	344	--	--	119	--
Iron		x	ug/l	**36,500**	--	--	7,000	2,580	--	--	2580	--	--	42.7	1,000
Lead		x	ug/l	**25**	15	50	--	--	--	--	--	--	--	--	
Manganese	x		ug/l	**1,990**	--	--	1,090	401	--	--	15	--	--	--	--
Mercury			ug/l	0.2	**2**	**2**	7	3	--	--	3	--	--	0.00405	0.012
Molybdenum			ug/l	--	--	100	**117**	43	--	--	43	--	--	--	--
Nickel	x	x	ug/l	57	--	--	**467**	172	--	--	172	--	--	231	--
Selenium		x	ug/l	2.2	50	**10**	117	43	--	--	43	--	--	124	5.0
Silver	x		ug/l	0.9	--	**50**	117	43	--	--	43	--	--	--	--
Thallium			ug/l	1.3	2	--	**1.87**	0.6	--	--	1	--	--	0.388	--
Uranium	x	x	ug/l	**88**	30	--	4.67	2	--	--	2	--	--	--	--
Vanadium			ug/l	28	--	--	**163**	60	--	--	60	--	--	--	--
Zinc	x	x	ug/l	190	--	--	**7,000**	2,580	--	--	2580	--	--	3,333	--

Constituent	Human Health COPC	Preliminary Ecological COPC[d]	Units	Background 95% UTL[h]	Potential ARARs			Risk-Based Concentrations[l]						Surface Water Protection	
								Ingestion			Ingestion + Sweat lodge				
					SDWA Drinking Water Standard	UMTRCA GW Protection[b]	Tribal HSCA[k]	HQ=1	Risk =10E-4	Risk =10E-6	HQ=1	Risk =10E-4	Risk =10E-6	Human Health[a]	Ecological[c]
Dissolved Inorganics															
Aluminum	x	x	ug/l	**5,231**	--	--	--	8,600	--	--	1298	--	--	--	--
Antimony			ug/l	**3.9**	--	--	--	3	--	--	3	--	--	--	--
Arsenic			ug/l	**106**	--	--	--	3	1	0.01	3	0.7	0.007	--	150
Barium			ug/l	68	--	--	--	602	--	--	**124**	--	--	--	--
Beryllium	x		ug/l	**0.79**	--	--	--	17	--	--	5	4	0.04	--	--
Cadmium	x	x	ug/l	0.27	--	--	--	**4**	--	--	**4**	5	0.05	--	0.25[g]
Chromium[j]			ug/l	**12**	--	--	--	--	--	--	2	0.1	0.001	--	74[g]
Cobalt	x		ug/l	**4.5**	--	--	--	172	--	--	6	3	0.03	--	--
Copper	x	x	ug/l	3.2	--	--	--	**344**	--	--	**344**	--	--	--	9.0[g]
Iron		x	ug/l	**55,035**	--	--	--	2,580	--	--	2580	--	--	--	--
Lead	x		ug/l	0.89	--	--	--	--	--	--	--	--	--	--	2.5[g]
Manganese	x		ug/l	**1,930**	--	--	--	401	--	--	15	--	--	--	--
Mercury			ug/l	0.2	--	--	--	**3**	--	--	**3**	--	--	--	0.77
Molybdenum			ug/l	**83**	--	--	--	43	--	--	43	--	--	--	--
Nickel	x	x	ug/l	14	--	--	--	**172**	--	--	**172**	--	--	--	52[g]
Selenium		x	ug/l	0.95	--	--	--	**43**	--	--	**43**	--	--	--	--
Silver	x		ug/l	1.2	--	--	--	**43**	--	--	**43**	--	--	--	3.2[g]
Thallium			ug/l	**1.1**	--	--	--	0.6	--	--	1	--	--	--	--
Vanadium			ug/l	4.8	--	--	--	**60**	--	--	**60**	--	--	--	--
Zinc	x	x	ug/l	181	--	--	--	**2,580**	--	--	**2580**	--	--	--	120[g]

identifies contaminants of concern (COCs) as determined in the human health risk assessment

Bolded value identifies the PRG for protection of human health. Where an ARAR concentration is available, the PRG is the higher of the ARAR concentration and background. Where no ARAR concentration is available, the PRG is the higher of the RBC and background. (Note: for risk-based concentrations based on cancer risk, only values corresponding to a 10-6 cancer risk were considered.)

-- indicates no value is available

[a]Spokane Tribe water quality standard or national recommended water quality criteria for consumption of water and organisms. Tribe standards for spiritual or ceremonial use are not included. Assumes no dilution of groundwater by surface water containing lower concentrations of COPCs.

[b] Uranium Mill Tailings Radiation Control Act (UMTRCA). Maximum Concentration of Constituents for Groundwater Protection, listed in 40 CFR Part 192, Subpart A, Table 1.

[c]Spokane Tribe water quality standard or national recommended water quality criterion for protection of aquatic organisms. Assumes no dilution of groundwater by surface water containing lower concentrations of COPCs.

[d]Preliminary ecological COPCs for surface water, based on contamination of surface water being the primary ecological concern for groundwater.

[e]Combined Radium 226 and Radium 228

[f]Combined Uranium 234 and Uranium 238

[g]The associated surface water criterion is hardness dependent; calculated at hardness of 100 mg/L as CaCO3. Actual surface water ARAR is equation used to derive this value.

[h] 95% upper tolerance limit

[i]pH 6.5-9.0

[j]Chromium VI toxicity criterion was used in the calculation of the Tribal PRG.

[k] Spokane Tribe of Indians (STI) Hazardous Substances Control Act - Table A1. Groundwater Cleanup Levels Protective of the Human Health.

[l]Risk-based concentrations are based on the following tribal-specific exposure parameters:

Exposure duration = 70 years

Ingestion rate = 4 liter/day (adult) and 2 liter/day (child)

Vapor inhalation rate (sweat lodge) = 0.83 m^3/day (adult) and 0.42 m^3/day (child)

Table 2-12
Potential PRGs for Surface and Stockpiled Material

Constituent	Human Health COPC	Preliminary Ecological COPC	Units	Background 95% UTL[a]	Human Health Values					Ecological Values
					UMTRCA[b]	Tribal HSCA[e]	Risk-Based Concentrations for Ingestion[f]			Lowest Ecological Benchmark[c]
							HQ=1	Risk =10E-4	Risk =10E-6	
Radionuclides										
Lead 210	x		pCi/g	**7.5**	--	0.0368	--	4.9	0.049	--
Polonium 210			pCi/g	**5.7**	--	--	--	16	0.16	--
Radium 226	x	x	pCi/g	**4.7**	9.7/19.7	0.134	--	18	0.18	--
Radium 228		x	pCi/g	**3.8**	8.8/18.8	0.0427	--	6	0.06	--
Thorium 227			pCi/g	0.44	--	--	--	95	**0.95**	--
Thorium 228	x		pCi/g	**3.9**	--	0.121	--	16	0.16	--
Thorium 230			pCi/g	4.4	**9.4/19.4**	--	--	65	0.65	--
Thorium 232		x	pCi/g	3.7	**8.7/18.7**	--	--	56	0.56	--
Uranium 234		x	pCi/g	**18**	--	--	--	83	0.83	--
Uranium 235		x	pCi/g	0.51	--	0.6	--	80	**0.80**	--
Uranium 238		x	pCi/g	**14**	--	0.466	--	62	0.62	--
Total Inorganics										
Aluminum		x	mg/kg	18,453	--	**40,000**	57,333	--	--	50
Antimony			mg/kg	1.3	--	**16**	23	--	--	**5**
Arsenic	x	x	mg/kg	**86**	--	0.117	29	20	0.20	10
Barium			mg/kg	401	--	**2,800**	4,013	--	--	500
Beryllium			mg/kg	1.3	--	**80**	115	--	--	10
Cadmium		x	mg/kg	0.32	--	**20**	57	--	--	3
Chromium[d]	x	x	mg/kg	18	--	**200**	86,000	--	--	0.4
Cobalt			mg/kg	21	--	**2,400**	1,147	--	--	20
Copper		x	mg/kg	42	--	**1,490**	2,293	--	--	50
Iron		x	mg/kg	**33,521**	--	12,000	17,200	--	--	200
Lead		x	mg/kg	13	--	--	--	--	--	50
Manganese		x	mg/kg	1,445	--	**1,870**	2,676	--	--	100
Mercury			mg/kg	0.10	--	**12**	17	--	--	0.1
Molybdenum		x	mg/kg	4	--	**200**	287	--	--	2
Nickel		x	mg/kg	21	--	**800**	1,147	--	--	30
Selenium	x	x	mg/kg	0.52	--	**200**	287	--	--	1
Silver			mg/kg	0.11	--	**200**	287	--	--	2
Thallium	x	x	mg/kg	0.22	--	**3.2**	4	--	--	1
Uranium	x	x	mg/kg	**43**	--	8	11	--	--	5
Vanadium	x	x	mg/kg	40	--	**280**	401	--	--	2
Zinc		x	mg/kg	51	--	**12,000**	17,200	--	--	50

identifies contaminants of concern (COCs) as determined in the human health risk assessment

Bolded value identifies the PRG for protection of human health. Where an ARAR concentration is available, the PRG is the higher of the ARAR concentration and background. Where no ARAR concentration is available, the PRG is the higher of the RBC and background. (Note: for risk-based concentrations based on cancer risk, only values corresponding to a 10-6 cancer risk were considered.)

Note: Exposures to airborne radon will also be addressed through surface and stockpiled material response actions.

-- indicates no value is available

[a] 95% upper tolerance limit

[b] Uranium Mill Tailings Radiation Control Act (UMTRCA). Activity concentration averaged over 100 square meters. The first number is the activity concentrationx averaged over first 15 cm of soil below surface (background plus 5 pCi/g). The second number is the activity concentration averaged over 15 cm thick layers of soil more than 15 cm below surface (background plus 15 pCi/g).

[c] Screening benchmarks for plants, soil microorganisms, and earthworms published by Oak Ridge National Laboratory (ORNL) (Efroymson et al. 1997a,b). Note: ecological benchmarks are not based on site-specific conditions and do not represent PRGs.

[d] 1:6 ratio of Cr VI:Cr III

[e] Spokane Tribe of Indians (STI) Hazardous Substances Control Act - Table B.1 Soil/Sediment Cleanup Levels Estimated to be Protective of the Human Health.

[f] Risk-based concentrations are based on the following tribal-specific exposure parameters:
Exposure duration = 70 years
Ingestion rate = 300 mg/day

Table 2-13
Potential PRGs for Sediment

Constituent	Human Health COPC	Preliminary Ecological COPC[b]	Units	Background 95% UTL[c]	Human Health Values				Ecological Values	
					Tribal HSCA[d]	Human Health Risk-Based Concentrations for Ingestion[f]			Ecological Benchmark[a]	Tribal HSCA[e]
						HQ=1	Risk =10E-4	Risk =10E-6		
Radionuclides										
Lead 210	x		pCi/g	**20**	0.0368	--	4.9	0.049	--	--
Polonium 210			pCi/g	**17**	--	--	16	0.16	--	--
Radium 226	x	x	pCi/g	**13**	0.134	--	18	0.18	--	--
Radium 228		x	pCi/g	**5.3**	0.0427	--	6	0.06	--	--
Thorium 227			pCi/g	0.88	--	--	95	**0.95**	--	--
Thorium 228			pCi/g	**6.0**	0.121	--	16	0.16	--	--
Thorium 230			pCi/g	**8.1**	--	--	65	0.65	--	--
Thorium 232		x	pCi/g	**5.1**	--	--	56	0.56	--	--
Uranium 234	x	x	pCi/g	**41**	--	--	83	0.83	--	--
Uranium 235		x	pCi/g	**2.3**	0.6	--	80	0.80	--	--
Uranium 238	x	x	pCi/g	**31**	0.466	--	62	0.62	--	--
Total Inorganics										
Aluminum		x	mg/kg	22,906	**40,000**	57,333	--	--	9,400	--
Antimony		x	mg/kg	1.0	**16**	23	--	--	0.49	--
Arsenic		x	mg/kg	**181**	0.117	29	23	0.23	9.8	9.79
Barium		x	mg/kg	368	**2,800**	4,013	--	--	500	--
Beryllium		x	mg/kg	2.5	**80**	115	--	--	0.7	--
Cadmium	x	x	mg/kg	1.0	**20**	57	--	--	0.99	0.99
Chromium		x	mg/kg	23	**200**	86,000	--	--	43	43.4
Cobalt	x	x	mg/kg	14	**2,400**	1,147	--	--	20	--
Copper		x	mg/kg	35	**1,490**	2,293	--	--	32	31.6
Iron		x	mg/kg	**28,442**	12,000	17,200	--	--	10,000	--
Lead			mg/kg	21	--	--	--	--	36	35.8
Manganese	x	x	mg/kg	1,179	**1,870**	2,676	--	--	740	--
Mercury		x	mg/kg	0.13	**12**	17	--	--	0.18	0.18
Molybdenum		x	mg/kg	11	**200**	287	--	--	--	--
Nickel	x	x	mg/kg	23	**800**	1,147	--	--	23	22.7
Selenium		x	mg/kg	1.7	**200**	287	--	--	0.1	--
Silver		x	mg/kg	0.15	**200**	287	--	--	0.5	--
Thallium	x		mg/kg	0.45	**3.2**	4	--	--	3.8	--
Uranium	x	x	mg/kg	**93**	8	11	--	--	17	--
Vanadium		x	mg/kg	41	**280**	401	--	--	--	--
Zinc		x	mg/kg	132	**12,000**	17,200	--	--	120	121

identifies contaminants of concern (COCs) as determined in the human health risk assessment

Bolded value identifies the PRG for protection of human health. Where an ARAR concentration is available, the PRG is the higher of the ARAR concentration and background. Where no ARAR concentration is available, the PRG is the higher of the RBC and background. (Note: for risk-based concentrations based on cancer risk, only values corresponding to a 10-6 cancer risk were considered.)
Note: Exposures to airborne radon will also be addressed through sediment response actions.
-- indicates no value is available

[a] Proposed sediment benchmarks are initially derived from the Consensus-based TEC database (MacDonald, 2000). If a Consensus-based TEC value was not available, then the lowest Sediment Quality Guideline (SQG) was selected as the benchmark. All SQG values, except uranium, are derived from EVS Environmental Consultants (1998). Uranium is derived from Environment Canada (2000) guidelines. Note: ecological benchmarks are not based on site-specific conditions and do not represeent PRGs.

[b] Preliminary ecological COPCs for radionuclides are for combined surface water and sediment.
[c] 95% upper tolerance limit
[d] Spokane Tribe of Indians (STI) Hazardous Substances Control Act - Table B.1 Soil/Sediment Cleanup Levels Estimated to be Protective of the Human Health.
[e] Spokane Tribe of Indians (STI) Hazardous Substances Control Act - Table C.1 Sediment Cleanup Levels Estimated to be Protective of Bottom Dwelling Organisms.

[f] Risk-based concentrations are based on the following tribal-specific exposure parameters:
Exposure duration = 70 years
Ingestion rate = 300 mg/day

Table 2-14
Summary of COCs and Preliminary Remediation Goals for Protection of Human Health

Primary Medium of Concern	COC	Units	PRG[a]	Basis
Surface and Stockpiled Material	Uranium (total)	mg/kg	43	Background
	Lead^{210}	pCi/g	7.5	Background
	Radium^{226}	pCi/g	4.7	Background
Sediments	Uranium (total)	mg/kg	93	Background
	Manganese	mg/kg	1,870	ARAR[b]
	Lead^{210}	pCi/g	20	Background
	Uranium^{238}	pCi/g	31	Background
	Uranium^{234}	pCi/g	41	Background
	Radium^{226}	pCi/g	13	Background
Surface Water	Uranium (total)	ug/L	20	Background
	Manganese	ug/L	72	Background
	Lead^{210}	pCi/L	2.5	Background
	Uranium^{238}	pCi/L	7.6	Background
	Uranium^{234}	pCi/L	8.8	Background
Groundwater	Uranium (total)	ug/L	88	Background
	Manganese	ug/L	1,990	Background
	Uranium^{238}	pCi/L	35	Background
	Uranium^{234}	pCi/L	37	Background
Air	Radon^{222}	pCi/m^2-sec	20	ARAR[c]

[a]PRG is lowest of risk-based criteria and potential ARARs criteria, but not less than background. Risk-based criteria for cancer risk are based on a 1 in 1,000,000 risk.
[b]Tribal Hazardous Substances Control Act
[c]Uranium Mill Tailings Radiation Control Act (UMTRCA) (40 CFR 192.02) and National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR 61)

PRG preliminary remediation goal
mg/kg milligrams per kilogram
pCi/g picoCuries per gram
ug/L micrograms per liter
pCi/L picoCuries per liter
pCi/m^2-sec picoCuries per meter squared per second

Table 2-15
Summary of Risks Drivers and Preliminary Remediation Goals for Protection of Ecological Receptors

Medium of Concern	Risk Driver	Units	PRG	Basis
Surface Water	Aluminum, total	ug/L	9,073	Background
	Barium, total	ug/L	165	Background
	Beryllium, total	ug/L	0.53	Benchmark, EPA Regions 4 and 9
	Cadmium, dissolved	ug/L	2.0 (acute)/0.5 (chronic)[a]	National recommended water quality criterion (acute)/background (chronic)
	Cobalt, total	ug/L	3	Background
	Copper, dissolved	ug/L	13.4 (acute)/8.96 (chronic)[a]	Tribal water quality standards
	Lead, dissolved	ug/L	64.6 (acute)/2.52 (chronic)[a]	Tribal water quality standards
	Manganese, total	ug/L	80	Benchmark, EPA Region 9
	Nickel, dissolved	ug/L	468 (acute)/52 (chronic)[a]	Tribal water quality standards
	Silver, dissolved	ug/L	3.2 (acute)[a] /0.8 (chronic)	National recommended water quality criterion (acute)/benchmark (chronic)
	Uranium, total	ug/L	19.6	Background
	Zinc, dissolved	ug/L	114 (acute)/105(chronic)[a]	Tribal water quality standards
Surface and Stockpiled Material	Cadmium	mg/kg	0.32	Background
	Lead	mg/kg	12.8	Background
	Uranium	mg/kg	43.3	Background
Sediment	Chromium	mg/kg	43.4	Tribal sediment cleanup standard
	Manganese	mg/kg	1,179	Background
	Selenium	mg/kg	1.7	Background
	Uranium	mg/kg	93.2	Background
	Vanadium	mg/kg	41	Background

Notes
[a] Criteria are hardness dependent; PRG calculated at a hardness of 100 mg/L as $CaCO_3$. Actual ARARs are equations used to derive the values.
PRG preliminary remediation goal
ug/L micrograms per liter
mg/kg milligrams per kilogram

Table 2-16
Summary of Ore and Protore and Waste Rock Volumes and Areas

Waste Type	Stockpile or Area	Estimated Footprint Area (acres)	Estimated Volume (cy)
Ore and Protore	Protore Stockpile #1	1.7	45,000
	Protore Stockpile #2	1.4	40,500
	Suspected Protore Stockpile #1	2.5	71,000
	Suspected Protore Stockpile #2	0.5	2,500
	Ore Stockpile #3	2.4	72,000
	Protore Stockpile #4	4.8	250,000
	Ore and Protore Stockpile #5	2.4	42,000
	Ore and Protore Stockpile #6	14	611,000
	Ore Stockpile #7	2.4	64,000
	Lime Protore Stockpile #8	6.7	323,000
	Suspected Ore Stockpile Q2	1	21,000
	Total Ore and Protore	**40**	**1,540,000**
Waste Rock Piles	South Spoils	105.3	9,470,000
	East Dump	21	961,000
	Hillside Dump	26.7	2,450,000
	Pit 4 Dump and Ready-Line Area	10	382,000
	Area 5	34	1,530,000
	Total Waste Rock Piles	**197**	**14,800,000**
Waste Rock in Backfilled Pits	Boyd Pit (backfilled)	11.7	1,450,000
	Pit 2 (backfilled)	4.6	662,000
	Pit 2 West (backfilled)	1.2	86,000
	Adit Pit (partially backfilled)	1.1	11,000
	Total Waste Rock in Backfilled Pits	**19**	**2,200,000**
Totals		**256**	**18,500,000**

Source: EPA 2005

Table 2-17
Historic (1995-2004) Pumpback and Water Treatment Data

Year	Western Drainage to PCP, gals	PCP to Pit 3, gals	Pit 3 Pumping, gals	Pit 4 Pumping, gals	Plant Discharge, gals	Sludge Production, lbs
1995	NM	NM	NM	15,811,800	152,790,600	8,089,020
1996	NM	NM	NM	13,359,400	145,299,000	8,162,758
1997	NM	NM	NM	16,611,250	172,841,800	9,251,860
1998	NM	NM	146,643,566	15,041,498	165,237,300	9,031,050
1999	46,174,991	63,770,131	137,715,300	14,888,800	152,996,800	8,162,610
2000	41,751,680	52,294,100	126,039,003	12,908,200	136,409,563	7,773,690
2001	13,630,800	15,959,800	34,837,500	3,774,400	38,904,447	1,917,645
2002	32,698,100	40,179,800	53,384,600	7,374,446	62,116,209	1,356,050
2003	ND	ND	53,304,900	3,927,000	59,070,191	2,047,050
2004	ND	ND	ND	ND	44,491,390	1,699,830

Source: MFG (2004), DMC (2005)
NM = not measured
ND = no data

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

3.1 INTRODUCTION

In this section, technology types and process options are identified and screened for their effectiveness at achieving the RAOs. "Technology types" refers to categories of remediation processes, while "process options" refers to specific processes within each technology type category (EPA 1988). Technology types and process options were identified for each of four media - surface and stockpiled material, sediment, surface water, and groundwater – and for each GRA (see Section 2 for descriptions of GRAs). The "surface and stockpiled materials" media type includes backfilled or stockpiled ore, protore, waste rock, overburden, soil, and road materials. The "sediment" media type includes sediment present in open pits, ponds, and affected drainages. The "surface water" media type comprises seeps, ponded water, and water in open pits and affected drainages. The "groundwater" media type includes all subsurface water within the site boundaries.

The identification and screening of technologies was conducted using a two-step process. First, media-specific technology types and process options were identified for each medium and GRA and screened based on technical implementability. In the second step, the technology types and process options retained from step one were screened based on effectiveness, implementability, and cost. Technology types and process options retained at the conclusion of screening were then used to assemble remedial alternatives that meet the RAOs.

3.2 SCREENING OF TECHNOLOGIES

The purposes of technology screening are to identify a representative process option for each technology type retained for further consideration in the FS and to eliminate process options that do not appear promising. In some cases, more than one process option is retained for a technology type if two or more process options are sufficiently different in their performance that one would not adequately represent the other. Not all retained technologies and process options were used in the development of alternatives (Section 4).

3.2.1 Initial Screening

The initial level of screening evaluated the technical implementability of the technology types and process options, considering the characteristics of both the site and the waste. The site and waste characteristics considered during the initial screening included:

1. The volumes and areas of affected media (Section 2.6)
2. The types of COCs (metals and radionuclides) (Section 2.2)
3. The occurrence of ARD at the site

The initial screening process eliminated those technology types and process options known to have minimal effectiveness for remediation of the COCs, or which were not feasible given the site conditions (e.g., soil types, depth of COCs). Technology types and process options also were eliminated if they were not reasonably constructable, or were insufficiently proven. The results of the initial screening are summarized in tables presented in Appendix A.

3.2.2 Secondary Screening

The technology types and process options retained at the conclusion of the initial screening were subsequently evaluated against the three criteria of effectiveness, implementability, and cost. The secondary screening evaluation emphasized the effectiveness criterion, with less emphasis on the implementability and cost of each process option. During the evaluation, engineering judgments regarding relative effectiveness and cost of process options were made within a particular technology type, rather than across technology types. For example, the relative costs of cover process options were compared to each other, but were not compared to ex-situ treatment process options. The results of the secondary screening are summarized in tables presented in Appendix A.

3.2.2.1 Effectiveness Criterion

Effectiveness rates the technical effectiveness of the process to achieve the RAOs for a particular medium. Performance with respect to the specific COCs is evaluated, as well as other site-specific factors, such as depth of contamination, and the physical properties of the contaminated media. The primary focus is whether the process option is effective in addressing the estimated volume of contaminated medium within a reasonable time frame; the potential impacts to human health and the environment during the construction and implementation phase; and how proven and reliable the process option is for the COCs and site conditions.

3.2.2.2 Implementability Criterion

Implementability is based on technical and administrative factors that affect the ability to implement the process. Overall technical implementability was considered during the initial

level of screening, and the secondary evaluation therefore placed greater emphasis on the institutional aspects of implementability. These include the ability to comply with ARARs; availability and capacity of treatment, storage, and disposal services; and availability of equipment and expertise to design, install, and implement the process.

3.2.2.3 Cost Criterion

The cost criterion evaluates the costs of the various process options within a given technology type. The costs used for comparison were based on engineering judgment and are relative between process options presented within a specific remedial technology type. Cost alone was not used to reject a process option.

Both capital and O&M costs were evaluated, and the results are tabulated in Appendix A along with the other results of the secondary screening process. The relative costs are categorized as "low," "medium," "high," or "very high." Capital costs include the costs for initial implementation of the process option (such as construction activities). Capital costs for treatment process options also include short-term operation of the treatment process. O&M costs include costs to operate and maintain long-term treatment systems, or maintenance and repairs of a remedy. Management of residuals generated during treatment is also included in the O&M costs.

3.3 EVALUATION OF TECHNOLOGIES AND SELECTION OF REPRESENTATIVE PROCESS OPTIONS

The technology types and process options that were retained at the conclusion of the secondary screening process are summarized by medium in Table 3-1. Technology types and process options were selected from these tables to assemble the remedial alternatives, as discussed in Section 4. For process options that might require treatability testing, the need for such testing is considered in the development and evaluation of remedial alternatives (Section 4). Any treatability tests required for implementation of the remedy selected in the ROD will be conducted during the remedial design phase.

The technology types retained are summarized by medium in Sections 3.3.1 through 3.3.4.

3.3.1 Surface Water Technology Types Retained

For remediation of surface water under the GRAs Institutional Controls, the technology types retained include land use controls, access restrictions, and community awareness. All of these technology types could feasibly be used to reduce exposure to site contaminants.

Although the GRA Monitoring is not typically considered to have associated remedial technologies, the process options of long-term surface water monitoring and monitored natural attenuation are both retained for possible inclusion in remedial alternatives.

Containment technology types that were retained include surface water controls, using any of a number of potentially feasible process options, and physical barriers. The only technology type retained for the GRA Removal is dewatering.

Treatment technology types retained for surface water include continued operation of the existing WTP, both ex- and in-situ physical/chemical treatment, and both ex- and in-situ biological treatment.

For the GRA Surface Water Discharge, the technology type of discharge of treated water to surface water was retained for possible inclusion in remedial alternatives.

3.3.2 Groundwater Technology Types Retained

For remediation of groundwater under the GRAs Institutional Controls and Monitoring, the same technology types were retained as for surface water (see Section 3.3.1).

For the Containment GRA, the physical barriers technology type was retained with a single process option – compacted soil/clay barrier. Two technology types were retained for the Removal GRA – passive removal (drainage) and active removal using either extraction trenches or wells.

The treatment technology types retained for groundwater included all those retained for surface water (Section 3.3.1), and expanded on the evaluation of ex-situ technology types by considering the categories “precipitation” and “separation.” These additional technology types are potentially applicable to the ex-situ treatment of both groundwater and surface water. Several process options are potentially feasible under these two technology types.

The technology type of treated water discharge to surface water is retained for the Water Discharge GRA, just as for treatment of surface water (Section 3.3.1).

3.3.3 Surface and Stockpiled Material Technology Types Retained

For remediation of surface and stockpiled material under the GRA Institutional Controls, the same technology types were retained as for surface water and groundwater (see Sections 3.3.1 and 3.3.2). Long-term monitoring of COCs was retained as a potentially feasible process option under the Monitoring GRA.

For the Containment GRA, several process options were retained under the technology type Covers and a single process option (retaining structures) was retained under the technology type Barriers.

Both offsite disposal and onsite disposal technology types were retained under the GRA Excavation, Transport, and Disposal. For the Treatment GRA, retained technology types consist of ex-situ physical/chemical treatment and in-situ biological treatment.

For the GRA Beneficiation/Processing, the technology type "resource recovery" was retained, with the single process option of off-site milling/physical separation.

3.3.4 Sediment Technology Types Retained

For remediation of sediment under the GRA Institutional Controls, the same technology types were retained as for other media (see Sections 3.3.1 through 3.3.3). Long-term monitoring of COCs was retained as a potentially feasible process option under the Monitoring GRA.

For the Containment GRA, only the technology type "barriers/source controls" is retained, with six process options considered potentially feasible under this technology type.

The technology types removal, and both onsite and offsite disposal were retained for the GRA Excavation, Disposal, and Transport, with several process options considered potentially feasible under each of these technology types.

Under the Treatment GRA, both ex-situ and in-situ physical/chemical treatment technology types were retained.

Table 3-1
Summary of Retained Technologies and Process Options

Medium	General Response Action	Remedial Technology	Retained Process Options
Surface Water[a]	No Action	None	None
	No Further Action	None	None
	Institutional Controls	Land Use Controls	Deed/Zoning Restrictions
		Community Awareness	Information and Education Programs
	Access Controls	None	Physical Restrictions (Fencing and Posted Warnings)
	Monitoring	None	Long-term Surface Water Monitoring
			Monitored Natural Attenuation [e]
	Containment	Surface Water Controls	Grading
			Revegetation
			Channelization
			Diversion Ditches
			Relocation
			Backfill (Partial or Full)
			Biostabilization
			Sedimentation Dams/Traps
			Passive Collection
		Physical Barriers	Hydraulic Isolation
	Removal	Dewatering	Complete Dewatering of open pits
			Partial Dewatering of open pits
			Gravity Drain
			Seep Collection
	Treatment	Continue Operating Existing WTP [b]	Chemical Precipitation
		Ex-Situ Physical/Chemical [b]	See retained process options for groundwater
		In-Situ Physical/Chemical	Neutralization/Precipitation
		Ex-Situ Biological Treatment	Ex-situ Anaerobic Bioreactors / Sulfate Reducing Bacteria (SRB)
		In-Situ Biological Treatment	In-situ Bacterial Reduction
			In-situ Biological Oxidation and Reduction
	Surface Water Discharge	On-Site Discharge of Treated Water	Surface Water Discharge

Table 3-1 (Continued)
Summary of Retained Technologies and Process Options

Medium	General Response Action	Remedial Technology	Retained Process Options
Groundwater	No Action	None	None
	No Further Action	None	None
	Institutional Controls	Land Use Controls	Deed/Zoning Restrictions
		Community Awareness	Information and Educational Programs
	Access Controls	None	Physical Restrictions (Posted Warnings and Well Security)
	Monitoring	None	Long-term Groundwater Monitoring
			Monitored Natural Attenuation [e]
	Containment	Physical Barriers	Compacted Soil/Clay Barrier
	Removal	Passive Removal / Drainage	Gravity Drain
		Active Removal / Hydraulic Barrier	Groundwater Extraction Trenches
			Groundwater Extraction Wells
	Treatment	Continue Operating Existing WTP [b]	Chemical Precipitation
		Ex-Situ Physical/Chemical [b]	Ion Exchange
			Neutralization/Precipitation
			Chemical Precipitation with Coagulation/Flocculation
			High Density Sludge (HDS)
			Tri-Media Filter
			Reverse Osmosis
		In-Situ Physical/ Chemical	Permeable Reactive Barrier (PRB) Wall
		Ex-Situ Biological Treatment	Ex-situ Anaerobic Bioreactors / Sulfate Reducing Bacteria (SRB)
		In-Situ Biological Treatment	In-situ Bacterial Reduction
	Water Discharge	On-Site Discharge of Treated Water	Surface Water Discharge

Table 3-1 (Continued)
Summary of Retained Technologies and Process Options

Medium	General Response Action	Remedial Technology	Retained Process Options
Surface and Stockpiled Material[c]	No Action	None	None
	No Further Action	None	None
	Institutional Controls	Land Use Controls	Deed/Zoning Restrictions
		Community Awareness	Information and Education Programs
	Access Controls	None	Physical Restrictions (Fencing and Posted Warnings)
	Monitoring	None	Long-term Monitoring of Contaminants of Concern (COCs)
	Containment	Covers	Surface Water Controls
			Regrading
			Vegetative Cover
			Compacted Soil/Clay Cover
			Multi-Layer Soil Cover
			Asphalt/Concrete Cover
			Geosynthetic Clay Liner (GCL) Cover
			Flexible Membrane Liner (FML) Cover
		Barriers	Retaining Structures
	Excavation, Transport, Disposal	Off-Site Disposal [b]	Existing Off-Site Landfill
			Existing Off-Site Disposal Site
		On-Site Disposal	Segregation
			Consolidation
			On-Site Repository / Disposal Area
			On-Site Repository built to RCRA Subtitle C Standards
			Disposal in Open Pits [c]
	Treatment	Ex-Situ Physical/Chemical	Ex-situ Solidification/ Stabilization (S/S)
			Neutralization
		In-Situ Biological Treatment	Bio-Solids Application
	Beneficiation / Processing	Resource Recovery	Off Site Milling/Physical Separation

Table 3-1 (Continued)
Summary of Retained Technologies and Process Options

Medium	General Response Action	Remedial Technology	Retained Process Options
Sediment[d]	No Action	None	None
	No Further Action	None	None
	Institutional Controls	Land Use Controls	Deed/Zoning Restrictions
		Community Awareness	Information and Educational Programs
	Access Controls	None	Physical Restrictions (Fencing and Posted Warnings)
	Monitoring	None	Long-term Monitoring of Contaminants of Concern (COCs)
	Containment	Barriers/Source Controls	Soil Cover
			Sedimentation Dams/Traps
			Channelization
			Diversion Ditches
			Biostabilization
			Burial
	Excavation, Transport, Disposal	Removal [b]	Mechanical Excavation/Dredging
			Suction Dredging
		Off-Site Disposal [c]	Existing Off-Site Landfill
			Existing Off-Site Disposal Site
		On-Site Disposal	Segregation
			Consolidation
			On-Site Repository / Disposal Area
			Disposal in Open Pits [d]
	Treatment	Ex-Situ Physical/Chemical	Ex-situ Solidification/ Stabilization (S/S)
			Neutralization
		In-situ Physical/Chemical	In-situ Solidification/ Stabilization (S/S)

Table 3-1 (Continued)
Summary of Retained Technologies and Process Options

Notes:
Multiple response actions and remedial technologies may be combined to develop effective alternatives.
Process options retained for additional evaluation may not be applicable to all locations of the site or conditions present at the site.
Some technologies presented in this table are applicable to still water, but not flowing water.
Based on the NCP, consolidation/containment remedial technologies are preferred for contaminated material with large volumes and low concentration levels.
Smaller volumes of material with higher concentrations are more suited for treatment.
If needed, treatability testing could be performed during the remedial design phase.
[a]Surface water includes seeps, water in open pits, ponded water, and affected drainages.
[b] Residuals produced during ex-situ physical/chemical treatment of water will likely be managed using one of the disposal process options. Disposal of residuals will depend on the treatment alternative selected. In addition, the residuals may go through additional treatment or waste minimization process prior to final disposal.
[c] Surface and stockpiled materials includes backfilled or stockpiled ore, protore, waste rock, overburden, soil, and road materials
[d] Sediment is present in open pits, ponds, and affected drainages.
[e] Monitored natural attenuation must be accompanied by source control.

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The primary objective of this phase of the FS is to develop an appropriate range of remedial alternatives that will protect human health and the environment and meet ARARs. The screening reduces the large number of candidate alternatives to a smaller, more manageable number of alternatives, which are analyzed more fully in the detailed analysis phase of the FS. The alternatives that have been developed are comprehensive, sitewide alternatives, consistent with EPA guidance.

This step of the FS process was previously documented in a technical memorandum entitled Development and Screening of Alternatives, Midnite Mine Superfund Site, Wellpinit, Washington (EPA 2003b). In that document, each candidate alternative is described and subjected to a preliminary evaluation of effectiveness, implementability, and cost consistent with EPA guidance (EPA 1988). This section presents a summary of the development and screening of candidate alternatives described in the technical memorandum.

Comments on the technical memorandum were received from stakeholders, including the Tribe, the mining company, and BLM. The technical memorandum was not reissued. However, one alternative (Alternative 5c) was added to the screening process based on stakeholder comments. The screening evaluation of Alternative 5c is presented in Section 4.3.6. The alternatives retained for detailed analysis in the FS, including Alternative 5c, are shown in Table 4-1.

Stakeholder comments and additional information have led to refinements of the retained alternatives and evaluation approach, including sludge disposal options. These refinements are not reflected in the screening, but are discussed in Section 5.

4.1 DEVELOPMENT OF CANDIDATE ALTERNATIVES

The candidate alternatives development process consists of six steps (EPA 1988):

1. Development of RAOs
2. Development of general response actions
3. Identification of volumes and areas of media to which general response actions might be applied
4. Identification and screening of technologies
5. Identification and evaluation of technology process options
6. Assembly of retained technologies into alternatives that are designed to achieve the RAOs

The preliminary RAOs, general response action, and volumes of areas of media to which general response actions might be applied are presented in Section 2. Identification and screening of technologies and identification and evaluation of technology process options are presented in Section 3. Alternatives that are designed to achieve the RAOs were assembled from the retained technologies. These alternatives are identified and briefly described in Section 4.2. Detailed descriptions of the alternatives are presented in the technical memorandum Development and Screening of Alternatives, Midnite Mine Superfund Site, Wellpinit, Washington (EPA 2003b).

4.2 DESCRIPTIONS OF CANDIDATE ALTERNATIVES

Five alternatives have been developed for the FS, including no action (Alternative 1), institutional controls (Alternative 2), and three active alternatives (Alternatives 3, 4, and 5). Alternatives 2 through 5 have two to six variants each, which are distinguished using a letter designation (for example, Alternative 2a). The alternatives are listed below.

Alternative 1 – No Action

Alternative 2 – Institutional Controls and Monitoring

Alternative 2a. Institutional Controls and Monitoring

Alternative 2b. Institutional Control, Monitoring, and Continued Existing Water Treatment

Alternative 3 – Above-Grade Containment of Surface and Stockpiled Materials, Open Pits Left Open, and Water Treatment

Alternative 3a. In-Place Containment of Surface and Stockpiled Materials and Existing Water Treatment

Alternative 3b. Consolidation and Containment of Surface and Stockpiled Materials and Upgraded Water Treatment

Alternative 3c. Consolidation and Containment of Surface and Stockpiled Materials and Expanded Water Collection and Treatment

Alternative 3d. Consolidation and Containment of Surface and Stockpiled Materials and In-Situ Groundwater and Pit Water Treatment

Alternative 3e. Consolidation and Containment of Surface and Stockpiled Materials, Pit 4 Backfilled with Waste Rock, and Water Treatment

Alternative 4 – Open Pits Backfilled Above Static Groundwater Level, Consolidation and Containment of Remaining Surface and Stockpiled Materials, and Existing Water Treatment

Alternative 4a. Consolidation of Surface and Stockpiled Materials in Unlined Pits and Water Treatment

Alternative 4b. Consolidation of Surface and Stockpiled Materials in Lined Pits and Water Treatment

Alternative 4c. Stabilization/Solidification and Consolidation of Surface and Stockpiled Materials in Pits and Water Treatment

Alternative 4d. Amendment and Consolidation of Surface and Stockpiled Materials in Pits and Water Treatment in Pit 3

Alternative 4e. Consolidation of Surface and Stockpiled Materials in Unlined Pits with Pit Drain and Water Treatment

Alternative 4f. Consolidation of Surface and Stockpiled Materials in Pits, Placement of Thick Cap Over Entire MA, Water Treatment, and Expanded Institutional Controls (Restricted Residential Use Scenario)

Alternative 5 – Complete Pit Backfill with Surface and Stockpiled Materials and Water Treatment

Alternative 5a. Consolidation of Ore, Protore, and Waste Rock in Open Pits with Pit Drains and Water Treatment

Alternative 5b. Consolidation of Waste Rock in Open Pits, Disposal of Ore and Protore in Offsite Repository, and Water Treatment

An additional variant on Alternative 5c was proposed by the Tribe, with the support of other Natural Resource Trustees following the initial screening process. The screening evaluation of Alternative 5c is presented in Section 4.3.6.

4.2.1 Alternative 1: No Action

Alternative 1 includes no actions to control exposures of humans and ecological receptors to contaminants. Under Alternative 1, operation of the existing water collection and treatment system would be discontinued. Maintenance of other engineered measures currently in place, such as revegetated waste materials and stormwater management systems, also would be discontinued. Consideration of the no action alternative is required by the NCP.

4.2.2 Alternative 2 Variants: Institutional Controls and Monitoring

Under Alternative 2, institutional controls would be used to limit exposure of humans and, to a lesser extent, ecological receptors to site contaminants. No new removal, containment, or treatment actions would be implemented; however, Alternative 2b includes continued O&M of the existing water collection and treatment system. A long-term monitoring program would be implemented to detect trends in environmental conditions within the MA, the drainages, and Blue Creek, including its delta in Lake Roosevelt.

Two variants of Alternative 2 were developed:

- Alternative 2a: Institutional Controls and Monitoring
- Alternative 2b: Institutional Controls, Existing Water Treatment and Disposal of Sludge (either on-site or off-site), and Monitoring

4.2.3 Alternative 3 Variants (Above-Grade Containment and Water Treatment)

Alternative 3 variants include above-grade containment of mining waste materials. The open pits remain open (with the exception of Alternative 3e, which includes backfilling Pit 4). The cover system includes a "thick" cap over areas containing ore and protore and a "thin" cap over other areas containing waste rock. To protect the containment systems constructed under Alternative 3 and reduce human health risks, institutional controls would prohibit residential use in the MA.

Various water and sludge management options are evaluated under Alternative 3, including:

- Existing treatment
- Upgraded treatment
- Expanded collection (including groundwater in the drainages) and treatment
- In-situ treatment, including permeable reactive barriers (PRBs) at existing seep collection points and lime neutralization of pit water
- Disposal of sludge in an onsite repository
- Disposal of sludge in a licensed, offsite disposal facility

An overview summary of the elements of the Alternative 3 variants is presented in Table 4-2.

4.2.4 Alternative 4 Variants (Partial Pit Backfill and Water Treatment)

Alternative 4 includes partial backfilling of Pits 3 and 4 to above the long-term static groundwater elevation to eliminate direct exposure to contaminated surface water and sediment. Pit 4 would be partially backfilled with waste rock from the Hillside Dump. Under Alternative 4, Pit 3 backfilling scenarios are:

- Unlined pit, backfilled using ore and protore (Alternative 4a)
- Lined pit, backfilled using ore and protore (Alternative 4b)
- Unlined pit, backfilled using solidified ore and protore (Alternative 4c)
- Unlined pit, backfilled using ore and protore amended with lime and organic material (Alternative 4d)

- Unlined pit, backfilled using ore and protore, with a passive drain to maintain the groundwater level below the ore and protore (Alternative 4e)

A restricted residential land use variant is evaluated under Alternative 4f. All other Alternative 4 variants include institutional controls that would prohibit residential use in the MA to limit human health risks and protect the containment systems. All of the Alternative 4 variants assumed onsite disposal of sludge if ex-situ treatment is included.

An overview summary of the elements of the Alternative 4 variants is presented in Table 4-3.

4.2.5 Alternative 5 Variants (Complete Pit Backfill and Water Treatment)

Alternative 5 includes complete backfill of the open pits with mining waste to pre-mining topography. Under Alternative 5a, all mining waste except that contained within the backfilled pits would be consolidated within the open pits. Under Alternative 5b, all waste rock except that contained within the backfilled pits would be consolidated within the open pits, and ore and protore would be excavated and disposed of offsite. Mining waste that could not be contained within the open pits would be mounded over the existing backfilled pits area and, if needed, the area between Pits 3 and 4 to enhance surface water runoff.

After implementation of Alternative 5, areas containing mining waste would be limited to the existing open pits, backfilled pits, and, if needed, the area between Pits 3 and 4. To protect the integrity of the containment systems, institutional controls would prohibit residential or industrial use in these areas. Residential use would not be prohibited in areas of the MA where materials would be removed to background concentrations or native material. Water treatment, if needed, and off-site sludge disposal was assumed for both Alternatives 5a and 5b.

An additional variant on Alternative 5c was proposed by the Tribe with support from other Natural Resource Trustees. The screening evaluation of Alternative 5c is presented in Section 4.3.6. An overview summary of the elements of the Alternative 5 variants is presented in Table 4-4.

4.3 SCREENING OF CANDIDATE ALTERNATIVES

In the screening step, each alternative is evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives are evaluated more generally in this phase than during the detailed analysis. However, the screening evaluation must be sufficiently detailed to distinguish among alternatives.

Under the effectiveness evaluation, each alternative is evaluated for its effectiveness in providing protection of human health and the environment and the reductions in toxicity, mobility, or volume it will achieve. Both short- and long-term components of effectiveness are evaluated. Short-term effectiveness refers to the construction and implementation period, and long-term effectiveness refers to the period after the remedial action is complete.

Under the implementability evaluation, the technical and administrative feasibility of constructing, operating, and maintaining each alternative is evaluated. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until an RA is complete. It also includes O&M, replacement, and monitoring of technical components of an alternative after the RA is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies and the availability of services, capacity, equipment, and technical specialists.

The cost evaluation compares the relative costs of the alternatives. Costs are typically not defined with the level of accuracy desired for the detailed analysis (i.e., +50 percent to -30 percent); however, the relative accuracy of the estimates should be consistent so that cost decisions among alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. The O&M costs are evaluated as present-worth costs, using a 7 percent discount rate and 30-year performance period, consistent with EPA guidance (EPA 2000b).

The results of the alternatives screening are summarized in Table 4-1.

4.3.1 Alternative 1

4.3.1.1 Effectiveness

Alternative 1 includes no actions to limit exposures of human or ecological receptors to COCs in source materials, sediments, surface water, groundwater, air, and plants. Alternative 1 would attain none of the RAOs in the foreseeable future.

4.3.1.2 Implementability

Because Alternative 1 includes no actions, it is not evaluated for implementability.

4.3.1.3 Cost

Alternative 1 includes no actions, hence, there would be no cost.

4.3.1.4 Screening Assessment

Consideration of the no action alternative is required by the NCP. Consequently, Alternative 1 is retained for detailed analysis in the FS.

4.3.2 Alternative 2 Variants

4.3.2.1 Effectiveness

Both Alternative 2 variants would protect human health by reducing exposure to COCs in contaminated media, including materials, sediments, surface water, groundwater, air, and plants, within the MA and other mine-affected areas using institutional controls, including access and use restrictions and informational programs. Use of institutional controls to reduce exposure to contaminated media is generally less reliable and permanent than engineered response actions such as containment or treatment. Alternative 2 generally would not reduce the exposure of ecological receptors to COCs, with the exception that fences would limit the access of large mammals to the MA.

Alternative 2b would provide additional protection from exposure to COCs in surface water in the drainages and Blue Creek relative to Alternative 2a by continuing the existing water collection and treatment program. Alternative 2b also would provide more protection from exposure to COCs in sediments than Alternative 2a by maintaining existing revegetated areas and the stormwater system, which would reduce erosion and transport of contaminated sediment.

4.3.2.2 Implementability

Alternative 2 would present relatively few implementability concerns. The primary implementability concern is disposal of water treatment sludge under Alternative 2b. Actions included under Alternative 2 are technically feasible, and the availability of materials and labor to conduct water treatment is not limited. The administrative implementability of institutional controls will depend, in part, on the regulatory mechanisms available to the Tribe and BIA.[5]

An onsite sludge disposal cell may be prohibited by the siting requirements set forth in HSCA. However, an onsite sludge disposal cell could be constructed in a manner that would comply with the substantive requirements of waste management ARARs. If offsite disposal of sludge is used instead of onsite disposal, it is anticipated that the sludge could be disposed of at the licensed radioactive waste disposal facility in Richland, Washington. The Richland facility has adequate capacity for the volume of waste that would be generated until approximately 2053. The facility has restrictions on the water content of waste it can accept, and further dewatering of the sludge prior to disposal probably would be required. In addition, stabilization or solidification would be required if the dewatered sludge would form free liquids during transport. Approval from the State of Washington Department of Health would be required for disposal of sludge at the Richland facility.

[5] Community and Tribal acceptance of institutional controls are not evaluated under the implementability criterion. Community and Tribal acceptance are evaluated based on comments received on the Proposed Plan, and this evaluation is presented in the Record of Decision.

4.3.2.3 Cost

The cost to implement, operate, and maintain Alternative 2 would be relatively low. The greatest cost uncertainty would be related to disposal of sludge generated by the treatment system under Alternative 2b after closure of the current disposal location at the Ford facility. A significant cost would be associated with construction of an onsite disposal cell. If onsite disposal is not used, offsite disposal would be costly due to disposal fees, sludge transportation, and additional sludge processing that may be required. The cost of offsite disposal is uncertain because both the quantities of sludge that would be generated and the unit cost of disposal would vary annually. The Richland facility is allowed a fixed maximum annual income by its license. As a result, the unit disposal cost would vary based on the total volumes and activities of waste disposed of at the facility by all generators within any year.

4.3.2.4 Screening Assessment

Alternative 2a would provide some protection of humans from exposure to COCs. However, Alternative 2a would not provide protection of the environment. It is less protective than existing measures being implemented by the mining company. Alternative 2a was not retained for detailed analysis in the FS.

Alternative 2b would provide additional protection of human health and the environment compared to Alternative 2a by treating contaminated surface water and reducing erosion of source materials in the MA. Alternative 2b also would provide a baseline similar to current conditions against which other, more comprehensive alternatives could be evaluated. Alternative 2b was retained for detailed analysis in the FS.

4.3.3 Alternative 3 Variants

4.3.3.1 Effectiveness

Alternative 3 variants would achieve adequate and similar levels of protection from exposure to COCs in surface and stockpiled material, sediment, groundwater, and air, with the primary exception that Alternative 3a would not reduce potential exposure to radon released from the Hillside Dump waste rock. The tradeoffs with respect to effectiveness mainly result from differences in the approaches used to protect surface water quality.

Alternative 3a would result in potential exposures at the Hillside Dump, as noted previously, which would be reduced by the other Alternative 3 variants. Alternative 3a would result in marginally higher releases of COCs to groundwater than the other Alternative 3 variants because percolation into the Hillside Dump waste rock would not be reduced. Alternative 3a would rely on access restrictions to reduce exposure of humans and other large mammals to surface water in the open pits.

Alternative 3b would result in a smaller volume of contaminated treatment residuals than Alternatives 3a, 3c, and 3e as a result of sludge dewatering.

Alternative 3c includes expanded water collection and treatment, and would likely result in the greatest improvements in water quality in the mine drainage streams and Blue Creek among the Alternative 3 variants.

Alternative 3d would potentially reduce the volume of contaminated treatment residuals produced compared to other Alternative 3 variants. Alternative 3d also would result in greater improvement in water quality in Pit 3 than other Alternative 3 variants. However, the performance and reliability of the technologies used to improve surface water quality is more uncertain than the technologies used under other Alternative 3 variants, and treatability studies would be required. Access restrictions may still be required to protect humans and other large mammals from surface water in the open pits.

Alternative 3e would eliminate the surface water exposure pathway in Pit 4. Although ecological receptors have begun to repopulate Pit 4 and consume water from Pit 4, the concentrations of COCs may exceed protective levels and Pit 4 could be considered an "attractive nuisance" to ecological receptors. The potential for poor quality groundwater to develop following placement of waste rock in Pit 4 would require evaluation.

4.3.3.2 Implementability

A primary implementability concern with Alternative 3 is the availability of clean cover material, including growth media. To date, suitable soil for construction of covers has not been identified at or near the site. If capping material is obtained from an offsite source that is not operating under an existing permit, a permit would be required to mine the material. Stripping soil from relatively large land areas to provide capping material may result in adverse environmental impacts, and reclamation of impacted areas may be required.

Alternative 3 is technically implementable. Disposal of sludge would be subject to similar implementability considerations as described in Section 4.3.2 for onsite (Alternatives 3a and 3e) or offsite (Alternatives 3b and 3c) disposal. Treatability studies would be required to design and select treatment media for in-situ water treatment included under Alternative 3d. There could be limitations in the availability of treatment media, depending on the media selected. Disposal of spent media would be subject to similar implementability considerations as described for treatment sludge in Section 4.3.2.

4.3.3.3 Cost

The estimated cost of Alternative 3a is the lowest of the Alternative 3 variants. The estimated cost of Alternative 3d is slightly higher, with higher capital costs for containment of Hillside Dump waste rock and construction of in-situ treatment systems but lower water treatment O&M costs. The estimated cost of Alternative 3b is higher than Alternative 3d due to higher O&M costs for active treatment and offsite sludge disposal compared to in-situ treatment. The estimated cost of Alternative 3c is higher than Alternative 3b because of the cost of expanded water collection and treatment. The estimated cost of Alternative 3e is the highest of all Alternative 3 variants, primarily due to the cost of consolidating the Hillside Dump waste rock in Pit 4.

The cost of each Alternative 3 variant is very sensitive to the volume of cover material required, the availability of cover material, and the distance the material must be hauled to the site. However, the effect of the uncertainty of cover material costs on the total estimated costs is approximately the same for all Alternative 3 variants.

In summary, the ranking of Alternative 3 variants with respect to relative cost, from lowest cost to highest cost, is 3a<3d<3b<3c<3e. However, the cost of the most expensive variant (3e) probably would not be more than 50% higher than the least expensive variant (3a).

4.3.3.4 Screening Assessment

Alternative 3a has the lowest estimated cost of the Alternative 3 variants. However, contaminated groundwater would continue to be released to surface water downgradient of the existing seep collection system. Because waste rock in the Hillside Dump would not be contained, there would be increased potential exposure to radon and increased loading of some COCs in groundwater relative to other Alternative 3 variants. Because other Alternative 3 variants (3c and 3d) appear to provide a greater risk reduction proportional to incremental costs, Alternative 3a was not retained for detailed analysis.

Alternative 3b would achieve similar levels of protectiveness as Alternative 3a, and the waste rock in the Hillside Dump would be contained. However, contaminated groundwater would also continue to be released to surface water downgradient of the existing seep collection system under Alternative 3b. Alternative 3b was not retained for detailed analysis, following the same reasoning used to eliminate Alternative 3a.

Alternative 3c would achieve similar levels of protectiveness as Alternative 3b, and contaminated groundwater would be collected and treated downgradient of the existing seep collection system, which would provide additional protection of human and ecological receptors from COCs in the mine drainage streams and Blue Creek. Alternative 3c was therefore retained for detailed analysis.

Alternative 3d would potentially provide additional protection of human and ecological receptors from exposures to COCs in open pit surface water relative to other Alternative 3 variants. Use of in-situ treatment under Alternative 3d would potentially reduce the long-term requirements for disposal of water treatment residuals. Although there is significant uncertainty about the long-term effectiveness of Alternative 3d, it potentially provides increased protection compared to alternatives that do not include in-situ pit water treatment and substantial O&M cost savings compared to alternatives that include active water treatment. Alternative 3d was therefore retained for detailed analysis.

Alternative 3e would eliminate a potential attractive nuisance to wildlife by backfilling Pit 4. However, the potential exists for poor quality groundwater to accumulate in and migrate out of a backfilled Pit 4. In addition, the estimated cost for containment of Hillside Dump waste rock in Pit 4 is greater than for in-place containment. Alternative 3e was therefore not retained for detailed analysis.

4.3.4 Alternative 4 Variants

4.3.4.1 Effectiveness

Alternative 4 variants would achieve adequate and similar levels of protection from exposure to COCs in surface and stockpiled material, sediment, groundwater, and air, and all variants would eliminate the exposure pathway to surface water in the open pits. With the exception of the restricted residential use variant, Alternative 4f, the tradeoffs with respect to effectiveness mainly result from differences in the approaches used to limit potential adverse effects to groundwater and surface water quality following placement of source materials in the open pits.

The quality of groundwater that would accumulate in the backfilled open pits under Alternative 4a is uncertain. If the groundwater contains sufficiently high levels of dissolved oxygen, or if the groundwater levels drops below the top of the backfilled ore and protore, ARD formation could occur. As a result, there is some potential that poor quality groundwater could accumulate in the pits and discharge to the surface water system downgradient of the MA. A treatability study would be required to evaluate the potential effects on surface water and groundwater.

Alternative 4b is less likely to result in poor groundwater quality in the pits than Alternative 4a because the ore and protore would be isolated from the groundwater system using a liner. However, the liner may not be fully effective due to the difficulty of installing a liner adjacent to the steep pit highwalls, including possible breaching of the liner due to hydrostatic pressure differentials between the inside and outside of the liner and differential settlement of materials inside and outside of the liner.

Alternative 4c would reduce water flow through the solidified/stabilized waste materials and would be expected to limit ARD generation to very low levels.

Alternative 4d would potentially reduce or eliminate production of contaminated treatment residuals. However, the performance and reliability of the in-situ treatment method used to improve water quality is uncertain, and a treatability study would be required.

Alternative 4e would reduce water flow through the source materials in the backfilled pits to very low levels and thereby limit ARD generation. The quality of water collected from the backfilled pits, the potential for additional ARD to form within the drain tunnel, and the need for treatment of the drain tunnel discharge would require further evaluation.

Alternative 4f would provide additional protection from radon and additional reduction of water percolation into source materials compared to the other Alternative 4 variants resulting from placement of a thick cap over all source materials. Since future residential use would be possible under Alternative 4f, the long-term integrity and effectiveness of the cap would depend, in part, on the effectiveness of institutional controls.

4.3.4.2 Implementability

Alternative 4 would have similar implementability considerations related to the availability of clean capping and backfill material as described under Alternative 3 in Section 4.3.3. Alternative 4f would require substantially more clean capping material than any other alternative. Under Alternative 4f, large volumes of clean capping material would be required to construct a thick cap over the entire site.

Disposal of sludge generated under Alternatives 4a, 4b, 4c, 4e, and 4f would be subject to similar implementability considerations as described for treatment sludge in Section 4.3.2. Alternative 4d could eliminate the need to identify an alternate long-term sludge disposal location.

Storage of untreated water is an implementability concern for Alternative 4. Construction activities would need to be sequenced so that adequate temporary untreated water storage capacity would be available after filling of Pit 3 begins. Following remedy construction, an alternate untreated water storage facility might be needed, particularly if year-round water treatment continued to be impractical.

There would be technical implementability considerations under Alternatives 4b, 4c, 4d, and 4e. Under Alternative 4b, the ability to construct a liner system adjacent to the steep pit highwalls would be a consideration. Under Alternative 4c, a treatability study would be required to design mix ratios and select reagents for stabilization/solidification of the ore and protore materials. Under Alternative 4d, treatability studies would be required to design and effectively operate the in-situ treatment of source materials and groundwater. Under Alternative 4e, detailed geotechnical and hydrogeological investigations would be required to select the best alignment for the passive drain tunnel. An additional concern under Alternative 4e is the possibility of

plugging the drain inlet, as a result of precipitation of metals and/or deposition of fine-grained soil, and the ability to conduct maintenance, should this condition occur.

The primary administrative implementability concern would be associated with Alternative 4f. Under Alternative 4f, the ability to implement the detailed land use management needed to protect the integrity of the cover systems under future residential use may be limited.

4.3.4.3 Cost

The estimated cost of Alternative 4a is the lowest of the Alternative 4 variants. Alternative 4d is the next highest, with higher capital costs than Alternative 4a due to the cost of amending the material placed in the open pits, but potentially lower operating costs resulting from in-situ water treatment in Pit 3.

The estimated costs of Alternatives 4b and 4e are the next highest, with higher costs than Alternatives 4a and 4d resulting from the cost of placing a liner in Pit 3 under Alternative 4b and the cost of installing a passive drain tunnel under Alternative 4e. The estimated costs cannot be differentiated between Alternatives 4b and 4e with the level of cost information available at the alternatives screening level.

The estimated costs of Alternatives 4c and 4f are substantially higher than the other Alternative 4 variants. The cost of solidification/stabilization of all ore and protore under Alternative 4c is very high. Alternative 4f has similar very high costs associated with constructing a thick cap over the entire site.

In summary, the ranking of Alternative 4 variants with respect to relative cost, from lowest cost to highest cost, is 4a<4d<4b≈4e<<4f<4c.

4.3.4.4 Screening Assessment

Alternative 4a would have the lowest capital costs of the Alternative 4 variants. However, Alternative 4a has uncertain effectiveness with respect to groundwater quality and associated water treatment requirements after the open pits have been backfilled. Alternative 4a was therefore not retained for detailed analysis.

Alternative 4b potentially provides greater protection of groundwater quality than Alternative 4a; however, the effectiveness and implementability of lining the pit highwalls are uncertain and the cost is higher than Alternatives 4a and 4d. Alternative 4b was therefore not retained for detailed analysis.

Alternative 4c also potentially provides greater protection of groundwater quality than Alternative 4a; however, the estimated cost is disproportionately high to the potential benefits. Alternative 4c was therefore not retained for detailed analysis.

Alternative 4d also potentially provides greater protection of groundwater quality than Alternative 4a. In addition, Pit 3 potentially could be used for in-situ treatment of contaminated water and eliminate concerns with long-term disposal of water treatment sludge. Although there is significant uncertainty about the long-term effectiveness of Alternative 4d, it potentially could realize substantial O&M cost savings compared to alternatives that include active treatment. Alternative 4d was therefore retained for detailed analysis.

Alternative 4e would reduce the potential for generation of ARD in Pit 3 by maintaining the groundwater level below the bottom of the ore and protore. Although the quantity and quality of water that would discharge from the passive drain, and the associated O&M costs, are uncertain, a passive drain would be a relatively reliable method of limiting ARD generation in Pit 3. Alternative 4e was therefore retained for detailed analysis.

Alternative 4f would further reduce radon flux and ARD generation relative to the other Alternative 4 variants by providing a thick cap over the entire site. Alternative 4f is the only variant that would enable restricted residential use. However, the cost of the alternative would be substantially greater than Alternatives 4a, 4b, 4d, and 4e, and its implementability would be further limited by the very large quantity of clean material that would be required for cap construction. Alternative 4f was therefore not retained for detailed analysis.

4.3.5 Alternative 5 Variants

4.3.5.1 Effectiveness

Alternative 5 would generally achieve the highest levels of protection from exposure to COCs in surface and stockpiled material, sediment, groundwater, and air of the candidate alternatives developed for the site. The materials would be consolidated within a smaller area under Alternative 5 than under other alternatives. As a result, land use restrictions would be needed for a smaller area. Potential exposures and acid generation from the pit highwalls would be eliminated.

Alternative 5a would reduce water flow through the source materials in the backfilled pits to very low levels and thereby limit ARD generation. The quality of water collected from the backfilled pits, the potential for additional ARD to form within the drain tunnels, and the need for treatment of the drain tunnel discharge would require evaluation.

Alternative 5b would eliminate onsite risks to ore and protore by disposing of these materials in an offsite repository. There would be short-term effectiveness considerations associated with waste hauling, including traffic impacts and the potential for offsite releases. Although waste rock with net acid neutralization potential would be placed in the pits below the long-term groundwater elevation, there would be potential for poor water quality to develop in the pits because the pits are not drained.

4.3.5.2 Implementability

Alternative 5 would have similar implementability considerations related to the availability of clean capping and backfill material as described in Section 4.3.3, but the quantities required would be somewhat less compared to Alternatives 3 and 4. Disposal of sludge would be subject to similar implementability considerations as described for in Section 4.3.2 for offsite (Alternative 5a) or onsite (Alternative 5b) disposal; however, it is anticipated the volume of sludge generated would be less than under Alternatives 2, 3, and 4. The need for an alternate untreated water storage facility to replace Pit 3 is an additional consideration, as described in Section 4.3.4.

Under Alternative 5a, an implementability consideration would be the ability to construct and maintain the passive drains. Detailed geotechnical and hydrogeological investigations would be required to select the best alignments for the drains. Gaining access to the drains from Pit 4, Pit 2, and the Boyd Pit to conduct maintenance activities (for example, in case of plugging) would be extremely difficult because both ends would be buried beneath tens of feet of backfill.

Under Alternative 5b, the capacity and material acceptability criteria of offsite disposal facilities are considerations. The large volume of ore and protore could approach or exceed available capacity at the Grandview, Idaho facility, depending on the volume of materials accepted from other sources and whether additional capacity is developed. The Richland facility will accept only 100,000 cubic feet of naturally-occurring radioactive material per year; therefore, it is not a potential disposal site for the ore and protore. The Grandview and Clive, Utah facilities both have concentration limits of 0.05% uranium.

4.3.5.3 Cost

Alternative 5 would reduce the area of capping compared to Alternatives 3 and 4; therefore, the cost of Alternative 5 relative to other alternatives would depend on the final cap design and the cost of providing suitable capping material. Nonetheless, preliminary estimates indicate the costs of both Alternative 5 variants would be high relative to all variants of Alternatives 1, 2, 3, and 4, except Alternatives 4c and 4f. The relatively high costs are primarily due to the capital cost of consolidating very large volumes of mining waste in the open pits. The estimated cost of Alternative 5b is high relative to Alternative 5a, due to the very high cost of offsite disposal of all ore and protore. The O&M costs of the Alternative 5 variants are relatively low because of the relatively small volumes of contaminated water that would require treatment and the relatively small cap areas that would require maintenance.

4.3.5.4 Screening Assessment

Alternative 5a would require relatively little O&M and would result in a relatively small disturbed area footprint. Alternative 5a would also limit impacts to groundwater and surface water. Although the cost of Alternative 5a is relatively high, it was retained for detailed analysis.

Alternative 5b would have similar benefits as Alternative 5a, and long-term onsite exposures to the most concentrated source materials would be eliminated by offsite disposal. However, the cost of Alternative 5b is high relative to Alternative 5a. Alternative 5b was therefore not retained for detailed analysis.

4.3.6 Screening of Additional Alternative

In response to comments by the Tribe and other Natural Resource Trustees, an additional alternative was screened subsequent to publication of the draft alternatives screening technical memorandum. This section presents a description of the alternative, which is designated Alternative 5c, and the results of the screening for effectiveness, implementability, and cost. Alternative 5c is based on information transmitted by the Tribe (AESE, Inc. 2003) and the Trustees (Midnite Uranium Mine Natural Resource Trustees Council 2004).

4.3.6.1 Description

Alternative 5c (Consolidation of Ore, Protore, and Waste Rock in Open Pits, Excavation of Backfilled Pits, and Water Treatment) includes the same elements as described under Alternative 5a (Section 4.2.5) plus:

- Flexible membrane liners (FMLs) would be placed in Pit 3 and 4 prior to placement of waste materials in the pits. Water that collects above the FMLs would be pumped out using extraction wells and treated.
- All waste rock in the backfilled pits would be excavated and placed in Pits 3 and 4. Rock would be excavated from the backfilled pits to the extent needed to provide gravity drainage from the excavated backfilled pits area to the Central Drainage.
- Water that collects within the drainage blankets in Pits 3 and 4 would be pumped out using extraction wells and treated, as needed.
- Areas where bedrock would be exposed by excavation would not be revegetated.
- The WTP effluent would be conveyed to the Spokane Arm of Lake Roosevelt for discharge.

4.3.6.2 Effectiveness

The effectiveness of Alternative 5c would be generally similar to Alternative 5a, with the following differences:

- Concentrations of COCs in surface water from the backfilled pits area under Alternative 5c would be reduced relative to concentrations of COCs in groundwater in backfilled pits under Alternative 5a (assuming groundwater would continue to collect in the backfilled pits after implementation of Alternative 5a). However, it is anticipated that surface water from the backfilled pits area would require treatment, and the volume of this water would be much larger than the volume of groundwater treated under Alternative 5a.
- The basal FML would provide additional isolation of waste materials and reduce migration of COCs into the drainage blanket, particularly during construction activities.
- Extraction wells would require more ongoing O&M than passive drains; however, maintenance would be easier to conduct and more likely to be successful compared to passive drains.
- Areas of bedrock would be subject to erosion, and sediment control structures would be required to limit sediment loads to the drainages.
- Discharge of WTP effluent in Lake Roosevelt would reduce loads of COCs and sulfate in the Eastern Drainage and Blue Creek. The discharge pipeline would require more maintenance than direct discharge to the Eastern Drainage.

4.3.6.3 Implementability

The implementability of Alternative 5c would be generally similar to Alternative 5a, with the following differences:

- The capacity of the pits is a greater implementability consideration under Alternative 5c than under Alternative 5a because an additional 2,200,000 cy of waste rock from the backfilled pits would be placed in Pits 3 and 4. It is anticipated that waste would be mounded over Pit 3 to a height that is several tens of feet above the pre-mining topography. Waste would also be mounded against the hillside that is northwest of Pit 4.
- Runoff rates from the excavated backfilled pits area would fluctuate widely in response to precipitation events. If the runoff requires treatment, the capacity of the WTP would have to be increased to accommodate these flows, because Pit 3 would not be available for temporary storage of untreated water.

4.3.6.4 Cost

It is anticipated that the total present worth cost and capital cost of Alternative 5c would exceed that of all Alternative 2, 3, and 4 variants and Alternative 5a, but would be less than Alternative 5b. It is anticipated that O&M costs would exceed that of Alternative 5b, but would be less than all Alternative 2, 3, and 4 variants and possibly Alternative 5a.

4.3.6.5 Screening Assessment

Alternative 5c would reduce the waste materials footprint and, therefore, cover materials requirements compared to Alternative 5a. In addition, O&M requirements may be reduced compared to Alternative 5a, particularly if treatment of runoff water from the excavated backfilled pits area is not required. The total present worth cost of Alternative 5c would be more than Alternative 5a, but less than Alternative 5b. Therefore, Alternative 5c was retained for detailed analysis.

4.3.7 Summary Of Alternative Screening

The following alternatives were retained for detailed analysis in the FS:

- Alternative 1
- Alternative 2b
- Alternative 3c
- Alternative 3d
- Alternative 4d
- Alternative 4e
- Alternative 5a
- Alternative 5c

The rationale for retaining these alternatives and screening out the remaining alternatives is presented in Sections 4.3.1 through 4.3.6 and Table 4-1.

Table 4-1
Summary of Alternatives Screening

Alternative	Description	Effectiveness	Implementability	Relative Cost		Screening Assessment
				Capital	O&M	
1	No Action	Does not protect human health or the environment	Not applicable	Low	Low	RETAINED Evaluation required by NCP
2a	Institutional Controls and Monitoring	Limited protection of human health, not protective of the environment	Readily implemented	Low	Low	NOT RETAINED Not protective
2b	Institutional Controls, Monitoring, and Continued Existing Water Treatment	Same as 2a, with reduced risks from exposure to surface water in the drainages and Blue Creek.	Implementable; alternate sludge disposal location must be identified.	Low	High	RETAINED
3a	In-Place Containment of Surface and Stockpiled Materials and Existing Water Treatment	Reduces risk from exposure to source materials and reduces loads of COCs in drainages and Blue Creek. Potential exposures to surface water in open pits. Potential exposure to radon at Hillside Dump.	Availability of capping material may be limited; alternate sludge disposal location must be identified.	Medium	Medium	NOT RETAINED - Less protective of surface water than Alternative 3c
3b	Consolidation and Containment of Surface and Stockpiled Materials and Upgraded Water Treatment	Similar to 3a, reduced exposure to radon at Hillside Dump.	Similar to 3a	Medium	Medium	NOT RETAINED Less protective of surface water than Alternative 3c
3c	Consolidation and Containment of Surface and Stockpiled Materials and Expanded Water Collection and Treatment	Similar to 3a, with additional improvements in surface water quality in drainages and Blue Creek.	Similar to 3a	Medium	Medium	RETAINED

Table 4-1 (Continued)
Summary of Alternatives Screening

Alternative	Description	Effectiveness	Implementability	Relative Cost		Screening Assessment
				Capital	O&M	
3d	Consolidation and Containment of Surface and Stockpiled Materials and In-Situ Groundwater and Pit Water Treatment	Similar to 3a, but with potentially improved water quality in open pits and reduced treatment residuals. A treatability study would be required to evaluate the effectiveness of in-situ treatment.	Similar to 3a, and requires treatability testing to design and implement in-situ treatment systems. May eliminate need for alternate sludge disposal after closure of Ford facility.	Medium	Low	RETAINED
3e	Consolidation and Containment of Surface and Stockpiled Materials, Pit 4 Backfilled with Waste Rock, and Water Treatment	Similar to 3a, plus surface water exposure pathway in Pit 4 would be eliminated. Potential for impacts to groundwater from waste rock placed in Pit 4 would require further evaluation.	Similar to 3a, and Pit 4 would need to be dewatered prior to fill placement.	Medium	Medium	NOT RETAINED Increased cost disproportionate to potential benefits relative to other Alternative 3 variants
4a	Consolidation of Surface and Stockpiled Materials in Unlined Pits and Water Treatment	Reduces risk from exposure to source materials, reduces loads of COCs in drainages and Blue Creek, and eliminates surface water exposure pathway in open pits. Potential for impacts to groundwater and surface water from source materials placed in open pits would require evaluation using treatability study.	Availability of capping material may be limited; alternate sludge disposal location must be identified. Alternate untreated water storage facility may be needed after Pit 3 is filled.	Medium	Medium	NOT RETAINED Potential for poor water quality in pits

Table 4-1 (Continued)
Summary of Alternatives Screening

Alternative	Description	Effectiveness	Implementability	Relative Cost		Screening Assessment
				Capital	O&M	
4b	Consolidation of Surface and Stockpiled Materials in Lined Pits and Water Treatment	Similar to 4a, but liner should limit groundwater and surface water impacts. Long-term effectiveness of liner would require evaluation.	Similar to 4a, and placement of liner adjacent to pit highwalls may be difficult.	High	Medium	NOT RETAINED - High cost and uncertain effectiveness and implementability
4c	Stabilization/Solidification and Consolidation of Surface and Stockpiled Materials in Pits and Water Treatment	Similar to 4a, but treatment should limit groundwater and surface water impacts.	Similar to 4a, and treatability studies would be required for stabilization/solidification. Material may require crushing prior to treatment.	Very High	Medium	NOT RETAINED - Very high cost
4d	Amendment and Consolidation of Surface and Stockpiled Materials in Pits and Water Treatment in Pit 3	Similar to 4a, but in-situ treatment may eliminate water treatment residuals. Long-term effectiveness of neutralization and in-situ water treatment would require evaluation.	Similar to 4a, and treatability studies would be required to design amendments and evaluate potential for water treatment in pits. May eliminate need for alternate sludge disposal after closure of Ford facility.	Medium	Low	RETAINED
4e	Consolidation of Surface and Stockpiled Materials in Unlined Pits with Pit Drain and Water Treatment	Similar to 4a, but pit drain should limit impacts on groundwater and surface water from source materials placed in Pit 3.	Similar to 4a, and a detailed geotechnical investigation would be required to select a suitable tunnel alignment. Ability to maintain passive drain, should plugging occur, may be limited.	High	Medium	RETAINED

Table 4-1 (Continued)
Summary of Alternatives Screening

Alternative	Description	Effectiveness	Implementability	Relative Cost		Screening Assessment
				Capital	O&M	
4f	Consolidation of Surface and Stockpiled Materials in Pits, Placement of Thick Cap Over Entire MA, and Expanded Institutional Controls (Restricted Residential Use Scenario)	Radon flux further reduced by thick cap over entire site, as exposure is potentially increased by residential use. Impacts to groundwater and surface water further reduced by thick cap. Cap integrity dependent on success of institutional controls.	Implementability limited by availability of very large volumes of clean material needed to construct thick cap. Detailed land use management needed to protect integrity of caps.	Very High	Low	NOT RETAINED Very high cost, implementability limited by availability of clean cover materials
5a	Complete Backfill of Open Pits with Ore, Protore, and Waste Rock and Water Treatment	Reduces risk from exposure to source materials, reduces loads of COCs in drainages and Blue Creek, eliminates surface water exposure pathway in open pits, and eliminates ARD generation on highwalls. Mine waste contained within a small area compared to Alternative 2, 3, and 4 variants. Potential for accumulation of poor quality groundwater in backfilled open pits should drainage system fail.	May reduce capping material requirements compared to other alternatives. Maintenance of passive drains from Pit 4, Pit 2, and the Boyd Pit would be extremely difficult, if needed. Ability to contain contaminated water after pit backfilling has started is a concern. Alternate untreated water storage facility may be needed after Pit 3 is filled.	Very High	Low	RETAINED

Table 4-1 (Continued)
Summary of Alternatives Screening

Alternative	Description	Effectiveness	Implementability	Relative Cost		Screening Assessment
				Capital	O&M	
5b	Complete Backfill of Pits with Waste Rock, Disposal of Ore and Protore in Existing Offsite Repository, and Water Treatment	Similar to 5a, and residual onsite risk from ore and protore eliminated. Potential for impacts to groundwater and surface water from source materials placed in open pits would require evaluation using a treatability study.	Potential limitations of licensed facilities to accept all ore and protore due to the volumes and radionuclide concentrations.	Very High	Low	NOT RETAINED - Very high cost
5c	Excavation of Existing Backfilled Pits, Complete Backfill of Open Pits with Ore, Protore, and Waste Rock, and Water Treatment	Similar to 5a. Excavation of existing backfilled pits would reduce generation of highly contaminated groundwater. COC loads in drainages and Blue Creek further reduced by piping WTP effluent to Lake Roosevelt. Area of mine waste containment further reduced.	Similar to 5a, and capacity of pits to contain all mine waste, including existing backfilled pits, is a greater concern. Drainage wells may require more frequent maintenance than passive drains, but would be more readily maintained.	Very High	Low	RETAINED

Table 4-2
Overview of Candidate Alternative 3 Variants

Site Element	Alternative				
	3a	3b	3c	3d	3e
Overview Description	In-Place Containment of Surface and Stockpiled Materials and Existing Water Treatment	Consolidation and Containment of Surface and Stockpiled Materials and Upgraded Water Treatment	Consolidation and Containment of Surface and Stockpiled Materials and Expanded Water Collection and Treatment	Consolidation and Containment of Surface and Stockpiled Materials and In-Situ Groundwater and Pit Water Treatment	Consolidation and Containment of Surface and Stockpiled Materials, Pit 4 Backfilled with Waste Rock, and Water Treatment
Surface Water Management	Collect clean runoff from undisturbed and capped areas and convey to drainages south of MA	Same as 3a	Same as 3a	Same as 3a	Same as 3a
Ore and Protore Stockpiles	Regrade in place and cap (thick cap)	Consolidate above backfilled pits and cap (thick cap)	Same as 3b	Same as 3b	Same as 3b
South Spoils	Regrade to 3H:1V and cap (thin cap)	Same as 3a	Same as 3a	Same as 3a	Same as 3a
Hillside Dump	No Action	Regrade to 3H:1V and cap (thin cap)	Same as 3b	Same as 3b	Consolidate in Pit 4 and cap (thin cap)
Other Waste Rock	Regrade to maximum 3H:1V and cap (thin cap); establish natural drainage patterns	Same as 3a	Same as 3a	Same as 3a	Same as 3a
Backfilled Pits	Regrade and cap (thick cap over ore and protore, thin cap over other areas)	Cap (thick cap)	Cap (thick cap), collect groundwater and treat	Same as 3b	Same as 3b
Pit 3	Leave open, pump and treat water, allow water level to rise as water quality improves, sediment left in place	Same as 3a	Same as 3a	Leave open, treat water in-situ using lime addition, allow water level to rise as water quality improves, sediment left in place	Same as 3a

Table 4-2 (Continued)
Overview of Candidate Alternative 3 Variants

Site Element	Alternative				
	3a	3b	3c	3d	3e
Pit 4	Leave open, pump and treat water, allow water level to rise as water quality improves, sediment left in place	Same as 3a	Same as 3a	Same as 3a	Backfill with waste rock from Hillside Dump and cap (thin cap); sediment buried beneath waste rock
Pit Highwalls	Fence to prevent access; no further action	Same as 3a	Same as 3a	Same as 3a	Pit 4 highwall eliminated; Pit 3 fenced to prevent access
Water Treatment	Existing system, with onsite sludge disposal after closure of Ford facility	Upgraded treatment system, with offsite sludge disposal after closure of Ford facility	Same as 3b	In-situ treatment	Same as 3a
South Spoils Seeps	Collect and treat, to the extent seeps exist after capping is implemented	Same as 3a	Same as 3a	Treat in-situ using PRBs	Same as 3a
Other PIA Seeps and Groundwater	No action	Same as 3a	Collect and treat or treat in-situ using PRBs	Same as 3a	Same as 3a
Drainage Sediments	Selected excavation, containment, or in-situ treatment	Same as 3a	Same as 3a	Same as 3a	Same as 3a
Haul Roads	Selected excavation or containment	Same as 3a	Same as 3a	Same as 3a	Same as 3a

Table 4-3
Overview of Candidate Alternative 4 Variants

Site Element	Alternative					
	4a	**4b**	**4c**	**4d**	**4e**	**4f**
Overview Description	Consolidation of Surface and Stockpiled Materials in Unlined Pits and Water Treatment	Consolidation of Surface and Stockpiled Materials in Lined Pits and Water Treatment	Stabilization/Solidi-fication and Consolidation of Surface and Stockpiled Materials in Pits and Water Treatment	Amendment and Consolidation of Surface and Stockpiled Materials in Pits and Water Treatment in Pit 3	Consolidation of Surface and Stockpiled Materials in Unlined Pits with Pit Drain and Water Treatment	Consolidation of Surface and Stockpiled Materials in Pits, Placement of Thick Cap Over Entire MA, and Expanded Institutional Controls (Restricted Residential Use Scenario)
Surface Water Management	Collect clean runoff from undisturbed and capped areas and convey to drainages south of MA	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a
Ore and Protore Stockpiles	Consolidate in Pit 3	Consolidate in lined Pit 3	Stabilize/solidify and consolidate in Pit 3	Amend with lime and organic material and consolidate in Pit 3	Same as 4a	Same as 4a
South Spoils	Regrade to 3H:1V and cap (thin cap)	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Regrade to 3H:1V and cap (thick cap)

Table 4-3 (Continued)
Overview of Candidate Alternative 4 Variants

Site Element	Alternative					
	4a	**4b**	**4c**	**4d**	**4e**	**4f**
Hillside Dump	Partial consolidation in Pit 4; regrade to 3H:1V; and cap (thin cap),	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a, capped using thick cap
Other Waste Rock	Regrade to 3H:1V and cap (thin cap), establish natural drainage patterns	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Regrade to 3H:1V and cap (thick cap)
Backfilled Pits	Regrade and cap (thin cap)	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a, capped using thick cap
Pit 3	Partial backfill with ore and protore and cap (thick cap); sediment buried beneath fill; install groundwater drain at approximately 2660 ft above msl	Line pit, partial backfill with ore and protore, and cap (thick cap); sediment buried beneath fill	Partial backfill with stabilized/solidified ore and protore and cover (soil cover); sediment buried beneath fill	Partial backfill with amended (with lime and organic material) ore and protore and cap (thick cap); sediment buried beneath fill	Excavate sediment; install gravity drain from pit bottom tunnel through quartz monzonite to discharge south of South Spoils; partial backfill with ore, protore, and sediment; and cap (thick cap)	Same as 4a
Pit 4	Partial backfill with waste rock from Hillside Dump and cap (thin cap); sediment buried beneath fill	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a, but with thick cap

Table 4-3 (Continued)
Overview of Candidate Alternative 4 Variants

Site Element	Alternative					
	4a	**4b**	**4c**	**4d**	**4e**	**4f**
Pit Highwalls	Height reduced by partial backfill; fenced to prevent access; runoff collected in perimeter drain for treatment	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a
Water Treatment	Existing system, with onsite sludge disposal after closure of Ford facility	Same as 4a	Same as 4a	Treat water in-situ in Pit 3. Collect and treat any pit discharge exceeding water quality standards using existing system.	Existing system plus collection and treatment of drainage tunnel discharge (if needed). Onsite sludge disposal after closure of Ford facility.	Same as 4a (if needed)
South Spoils Seeps	Collect and treat, to the extent seeps exist after capping is implemented	Same as 4a	Same as 4a	Same as 4a	Same as 4a	No action; seeps expected to dry up with thick cap over site
Other PIA Seeps and Groundwater	No action	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a

Table 4-3 (Continued)
Overview of Candidate Alternative 4 Variants

Site Element	Alternative					
	4a	**4b**	**4c**	**4d**	**4e**	**4f**
Drainage Sediments	Selected excavation, containment, or in-situ treatment	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Same as 4a
Haul Roads	Selected excavation or containment	Same as 4a	Same as 4a	Same as 4a	Same as 4a	Complete excavation or containment

Table 4-4
Overview of Candidate Alternative 5 Variants

Site Element	Alternative		
	5a	**5b**	**5c**
Overview Description	Complete Backfill of Open Pits with Ore, Protore, and Waste Rock and Water Treatment	Complete Backfill of Pits with Waste Rock, Disposal of Ore and Protore in Existing Offsite Repository, and Water Treatment	Excavation of Existing Backfilled Pits, Complete Backfill of Open Pits with Ore, Protore, and Waste Rock, and Water Treatment
Surface Water Management	Reestablish natural drainage patterns in Western Drainage; collect clean runoff from undisturbed and capped areas and convey to drainages south of MA	Same as 5a	Reestablish natural drainage patterns in Western Drainage; establish drainage from existing backfilled pits in Central Drainage; collect clean runoff from undisturbed and capped areas and convey to drainages south of MA
Ore and Protore Stockpiles	Excavate and consolidate in Pit 3	Excavate and dispose of in licensed offsite facility	Same as 5a
South Spoils	Excavate and consolidate in open pits	Same as 5a	Same as 5a
Hillside Dump	Excavate and consolidate in open pits	Same as 5a	Same as 5a
Other Waste Rock	Excavate and consolidate in open pits. Excess waste rock would be mounded over the existing backfilled pits area to enhance runoff.	Excavate and consolidate in open pits	Excavate and consolidate in open pits
Backfilled Pits	Cap (thick cap) and install gravity drain to Pit 3	Cap (thick cap)	Excavate and consolidate in open pits

Table 4-4 (Continued)
Overview of Candidate Alternative 5 Variants

Site Element	Alternative		
	5a	5b	5c
Pit 3	Complete backfill with ore, protore, and waste rock and cap (thick cap); install gravity drain	Complete backfill with waste rock and cap (thick cap)	Complete backfill with ore, protore, and waste rock and cap (composite cap). Includes basal FML and dewatering wells; mound excess material above pit at slope no steeper than 3H:1V.
Pit 4	Complete backfill with waste rock and cap (thick cap); install gravity drain to Pit 3	Complete backfill with waste rock and cap (thick cap)	Complete backfill with ore, protore, and waste rock and cap (composite cap). Includes basal FML and dewatering wells; mound excess material above pit at slope no steeper than 3H:1V.
Pit highwalls	Pit highwalls eliminated by complete backfill	Same as 5a	Same as 5a
Water Treatment	Existing system, with offsite sludge disposal after closure of Ford facility (if needed)	Same as 5a	Same as 5a
South Spoils Seeps	Collect and treat, to the extent seeps exist and exceed water quality standards after consolidation and capping is implemented	Same as 5a	Same as 5a
Other PIA Seeps and Groundwater	No action	Same as 5a	Same as 5a
Drainage Sediments	Selected excavation, containment, or in-situ treatment	Same as 5a	Same as 5a
Haul Roads	Selected excavation or containment	Same as 5a	Same as 5a

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

This section presents the detailed analysis of the retained alternatives using the CERCLA evaluation criteria. The evaluation criteria are described in Section 5.2. Section 5.3 presents the individual analysis portion of the detailed analysis, in which the alternatives are described in detail and evaluated individually using the CERCLA criteria. Section 5.4 presents the comparative analysis, in which the relative performance of each alternative under each criterion is evaluated.

5.2 ANALYSIS METHODS

There are nine CERCLA evaluation criteria, which are summarized in Table 5-1. These nine criteria are subdivided into three categories: threshold criteria, primary balancing criteria, and modifying criteria. The nine CERCLA criteria, grouped by category, are as follows:

Threshold criteria

1. Overall protection of human health and the environment
2. Compliance with ARARs

Primary balancing criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost of implementation

Modifying criteria

8. State/Tribal acceptance
9. Community acceptance

The three criteria categories are based on the role of each criterion during the evaluation and remedy selection process. The two threshold criteria relate directly to statutory requirements that must be satisfied by a selected alternative,[6] as ultimately documented in a ROD. The five primary balancing criteria represent the primary technical, cost, institutional, and risk factors that form the basis of the evaluation. The two modifying criteria are evaluated in the ROD following the receipt of state agency, Tribal, and public comments on the RI/FS and the Proposed Plan.

[6] An alternative that does not meet an ARAR may be selected under certain circumstances. 40 CFR 300.430(f)(1)(ii)(C).

Since the two modifying criteria are evaluated following public comment on the proposed plan and RI/FS, the FS evaluation considers only the seven CERCLA threshold and balancing criteria. The basis for the evaluation of the seven threshold and primary balancing criteria is discussed in the following sections.

5.2.1 Overall Protection of Human Health and the Environment

The criterion of overall protection of human health and the environment provides an assessment of whether each alternative provides adequate protection of human health and the environment. This evaluation criterion is an integration of the balancing criteria (particularly long-term effectiveness and permanence and short-term effectiveness) as well as compliance with ARARs. The integration includes consideration of how risks posed through each exposure pathway are eliminated, reduced, or controlled by the alternative—by treatment, engineering controls, institutional controls, or combinations of treatment and controls. Evaluation of this criterion also includes consideration of whether any unacceptable short-term or cross-media effects are posed by an alternative.

The evaluation provides a unified assessment of the balancing criteria and includes focused consideration of the rapidity, reliability, and permanence of the protection provided by each alternative. The combined effect of containment, treatment, and institutional controls is evaluated considering that a period of natural recovery following completion of remedial action would be needed to reach remediation goals and be fully compliant with ARARs.

In this FS, estimates were made of average annual uranium loads in the Eastern Drainage under each of the retained alternatives. The estimates provide an indication of the effects of the various alternatives on surface water quality in the Eastern Drainage and Blue Creek. The estimates were made for the Eastern Drainage at sampling location SW-06, which is located approximately 600 feet upstream of Blue Creek. The method used to estimate the uranium loads is described in Appendix F.

5.2.2 Compliance With ARARs

This criterion requires that the selected remedial alternative complies with applicable or relevant and appropriate requirements, unless a waiver is justified under CERCLA. ARARs include those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that are applicable or relevant and appropriate. Since this remedial action is on a Tribal Reservation, EPA will, as a matter of policy, apply Section 121 analysis to Tribal requirements in the same manner as it would evaluate similar state requirements.

In the FS, criteria are identified as "potential ARARs." Compliance of the FS alternatives with potential ARARs is discussed under each alternative. Potential ARARs used in the evaluation are presented in Section 2. Final ARARs are identified in the ROD.

The following paragraphs clarify how EPA interprets ARARs for environmental media where natural background conditions are higher than the specific numerical standards or the calculated standards of the ARAR.

To evaluate compliance with potential surface water, groundwater, sediment, and surface material ARARs, maximum site concentrations of COCs were compared to the most stringent applicable or relevant and appropriate standard and the 95% upper tolerance limit (95UTL) background concentration. In cases where the concentration of a COC exceeds both the background concentration and the standard, provided the ARAR allows for use of natural background in such cases, compliance of an alternative with the ARAR will be defined as achieving the background concentration or eliminating the exposure pathway(s).

EPA has determined that the Tribe's surface water quality standards allow for use of the background concentration as the standard where the numerical criterion is lower than the background concentration. (Section 3(2), Spokane Tribe of Indians Surface Water Quality Standards Resolution 2003-259, March 7, 2003.) Similarly, EPA has determined that the Tribe's HSCA allows for use of the background concentration as the cleanup standard for groundwater, soil, and sediment where the numerical criterion is lower than the background concentration. (Section 34-1.11(d), Spokane Tribe of Indians HSCA Resolution 2004-085, December 22, 2003.)

For surface water, the Tribal water quality standards for protection of human health for consumption of water and organisms, protection of human health for ceremonial and spiritual use, and protection of aquatic organisms are potentially applicable standards. The Clean Water Act national recommended water quality criteria for protection of human health for consumption of water and organisms, the Clean Water Act national recommended water quality criteria for protection of aquatic organisms, and the Safe Drinking Water Act primary drinking water standards are potentially relevant and appropriate standards.

For surface materials, the Tribal soil/sediment cleanup standards for protection of human health are potentially applicable, and the UMTRCA standards for radium are potentially relevant and appropriate outside waste containment areas. For sediment, the Tribal soil/sediment cleanup standards for protection of human health and the Tribal sediment cleanup standards for protection of sediment-dwelling organisms are potentially applicable.

For groundwater, it is assumed for the purposes of the ARARs analysis that a waste management area (WMA) would be established that consists of the areas within which mine waste is contained within the MA. CERCLA and the NCP require that groundwater should be returned to its beneficial uses within a reasonable time frame wherever practicable. When restoration of

groundwater is not practicable, then it is necessary to prevent further migration of the plume and to prevent exposure to the contaminated groundwater. (40 CFR.300.430[a][2]). The NCP provides that groundwater cleanup levels should generally be attained throughout the contaminated plume. However, the NCP recognizes that groundwater may remain contaminated at the edge of and within the WMA when waste is left in place (55 Fed. Reg. 8713, 8753, March , 1990). For groundwater outside of the WMA, the Tribal groundwater cleanup standards are potentially applicable standards. Safe Drinking Water Act primary drinking water standards and groundwater protection standards under UMTRCA are potentially relevant and appropriate for groundwater quality.

For air, the UMTRCA radon flux standard of 20 $pCi/m^2/s$ is potentially relevant and appropriate in waste containment areas. While not an ARAR, the principle of as "low as reasonably achievable" calls for reduction of radiation exposure to levels as close as possible to local background and is viewed as a to-be-considered material.

5.2.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence criterion relates to the magnitude of residual risks following remedy implementation and the adequacy and reliability of controls related to maintaining remedy effectiveness over time. Generally, the following factors are considered in the assessment of long-term effectiveness and permanence:

- Nature and magnitude of residual risks remaining from untreated waste or treatment residuals remaining at the end of remedial activities. The residual risks are considered from the standpoints of volume or concentration and potential for exposure of humans and environmental receptors. The characteristics of the residuals or untreated waste are considered in terms of their persistence, toxicity, mobility, and propensity (if any) to bioaccumulate.
- Adequacy and reliability of controls used to manage treatment residuals or untreated waste that remain at the site, including engineering controls, institutional controls, monitoring, and operation and maintenance. This assessment includes the potential need for replacement of components of the remedy and the continuing need for repairs to maintain the performance of the remedy.

Long-term effectiveness and permanence are of particular importance to the Tribe, whose finite reservation lands are intended to support the Tribe's resource uses and treaty rights.

- It is important to the Tribe that residual risks be minimized such that tribal members and tribal resources are not impacted. Tribal resources of particular concern are surface areas, surface water, groundwater and the use of these resources by tribal members for traditional and subsistence activities. It is important to the Tribe that the duration of residual risks also be minimized.

- The Tribe also has concerns about the long-term reliability of any treatment systems. This includes concerns regarding the long-term operation and maintenance of such systems, as well as the availability of long-term funding for such systems. In addition, the effectiveness of institutional controls at this site may lack certainty due to the regulatory context (e.g., limited Tribal mechanisms, allottee rights and federal jurisdiction).

5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The treatment criterion relates to the statutory preference for treatment technologies that permanently reduce the toxicity, mobility, or volume of hazardous substances as their principal element. Satisfaction of this preference occurs for inorganic chemicals when treatment is used to reduce the principal threats at a site through reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. Generally, the following factors are considered in the assessment of this criterion:

- Treatment processes and the materials to be treated
- Amount of hazardous contaminants to be destroyed or treated
- Degree of expected reduction in contaminant toxicity, mobility, or volume
- Degree to which the treatment is irreversible
- Quantity and type of residuals that will remain following treatment, considering their persistence, toxicity, and mobility

The statutory preference (but not necessarily the criterion) for reduction of toxicity, mobility, or volume through treatment is satisfied when treatment is used for the "principal threats" at the site. The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable.[7] EPA has also established an expectation for use of engineering controls, such as containment, for waste that poses a relatively low, long-term threat or where treatment is impracticable.[8] The extent of satisfaction of the preference is documented in the ROD, based on the selected remedy.

A "principal threat" is a material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure. Principal threats are those materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. EPA has not identified any of the wastes at the site as principal threat wastes.

[7] 40 CFR 300.430(a)(1)(iii)(A)
[8] 40 CFR 300.430(a)(1)(iii)(B)

5.2.5 Short-Term Effectiveness

The short-term effectiveness criterion relates to potential effects of the alternative during the construction and implementation phase of the remedy, until remedial action objectives have been met. Each alternative is evaluated in terms of its effectiveness in protecting human health and the environment during the construction and implementation phase. In the case of Midnite Mine, where each active alternative includes water treatment for the foreseeable future, this ongoing water treatment and disposal of residuals is evaluated under the short-term effectiveness criterion. The following factors, which are potentially extant during remedy construction and implementation, are considered:

- Short-term risks that might be posed to the community during construction and implementation (e.g., traffic-related risks from transporting material through a community to or from the site) and the effectiveness and reliability of protective measures
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures (e.g., airborne dust controls to minimize worker exposure to airborne contaminants)
- Potential environmental impacts of the remedial action and the effectiveness and reliability of available mitigation measures during construction and implementation
- Time until protection is achieved

5.2.6 Implementability

The implementability criterion relates to the technical and administrative feasibility of implementing an alternative and the availability of services and materials required for implementation. Generally, the following technical feasibility, administrative feasibility, and availability factors are evaluated for each alternative:

- Technical feasibility
  - Degree of difficulty or uncertainty associated with construction and operation of the technology associated with the alternative
  - Expected operational reliability of the technologies associated with the alternatives and the ability to undertake additional or supplemental action, if required
  - Extent to which innovative or untried technologies are used, and associated risks or needed treatability studies (this could include passive water treatment systems, wetland treatment systems, and soil treatment technologies)
  - Ability to monitor the effectiveness of the alternative, including potential exposure risks should monitoring not detect a “failure” of the alternative

- Administrative feasibility
  - Ability and time required to meet the substantive requirements of ARARs or to obtain any necessary permits from regulatory agencies
  - Activities needed to coordinate with other agencies
- Availability of services and materials
  - Availability of necessary equipment and skilled workers
  - Available capacity and location of needed treatment, storage, and disposal services
  - Availability of prospective technologies under consideration
  - Availability of (clean) cover material and topsoil

A potential administrative feasibility consideration is the ability to implement effective institutional controls on Tribal and allotment lands. Disposal of WTP sludge on the reservation, use of borrow material from the site or elsewhere on the reservation, and permanent encumbrances on trust lands involve use of finite Tribal resources and are difficult to implement without the support of the Tribe. Such actions will require coordination and consultation with the Tribe, in addition to extensive coordination with the BIA.

5.2.7 Cost of Implementation

Cost estimates for this FS were developed consistent with EPA guidance (EPA 2000b). The estimated cost of implementation for each alternative is expressed as a present worth cost. Estimated costs include the sum of direct capital costs, indirect capital costs, and O&M costs. Estimated quantities used in the cost estimates are described in Appendix C. Estimated unit costs used in the cost estimates are described in Appendix D.

5.2.7.1 Direct Capital Costs

Capital costs consist of direct and indirect costs. Direct capital costs are commonly referred to as construction costs, and consist of the equipment, labor, and materials necessary to install remedial actions. Direct costs specifically include costs associated with containment, treatment, or removal, transport, and disposal of affected media (including soil, sediment, and water).

5.2.7.2 Indirect Capital Costs

Indirect capital costs consist of expenditures required to complete the installation of a remedial alternative, including contingency cost, that are not included as a direct capital cost. Such indirect capital costs include engineering, construction management, and project management (including contract administration, permitting, and legal costs). Although these indirect capital costs may be referred to as “non-construction” and overhead costs, they are required to

implement the remedy. In this FS, indirect costs have been estimated to be 30 percent of direct capital costs.

The contingency cost is an allowance for potential costs associated with adverse site, design, or construction conditions not otherwise anticipated in the cost estimate. The contingency does not include any potential future remedial action costs associated with failure of the remedy to perform within expected limits. In this FS, contingency costs have been estimated to be 30 percent of direct capital costs.

5.2.7.3 Operation and Maintenance Costs

Annual O&M costs consist of post-construction costs necessary for continued effectiveness of the remedial action. These O&M costs include:

- Operating labor, materials, utilities, and administration
- Disposal of treatment residues (e.g., sludge from water treatment plant operations)
- Routine and special maintenance
- Rehabilitation, as structures or equipment wear out or fail over time
- Insurance, taxes, and licensing fees
- Long-term monitoring, including planning, sampling, analysis, and reporting
- Periodic site reviews[9] of the remedy

Similar to capital costs, a contingency of 30 percent of O&M costs has been included in the estimated costs in this FS.

5.2.7.4 Present Worth Analysis

The total cost of each alternative is represented as a "present worth cost." The present worth cost is the sum of the direct and indirect capital costs and the present worth of the future O&M cost over the period of performance of the alternative. The present worth cost represents the amount of money that, if invested in the current year and disbursed as necessary, would be sufficient to cover all costs associated with the remedial action over its planned life. Since remedial actions have not been staged or phased over time in the FS, all capital costs are considered present worth costs assuming year 2003 dollars.

Consistent with current CERCLA guidance, estimates of O&M present worth costs have been developed assuming a real discount rate of 7 percent and a 30-year period of performance. To

[9] Site reviews must be conducted at least every 5 years if hazardous substances remain on site above levels that allow for unrestricted use and unlimited access.

more fully evaluate potential costs, estimates of O&M present worth costs have also been developed assuming a real discount rate of 3.1 percent and a 140-year period of performance. This discount rate is the rate presented in the January 2005 update of the Office of Management and Budget *Circular A*-94, and represents the discount rate to be used in benefit-cost and other types of economic analysis for federal programs for the period February 2005 to January 2006. The period of performance represents seven generations of the Spokane Tribe, assuming each generation equals 20 years.

The present worth of O&M can also be evaluated for other discount rates and periods of performance. The estimated present worth of O&M will be higher for lower discount rates and longer periods of performance. Approximate present worth (PW) O&M costs for any combination of discount rate and period of performance (PW(X%,Y)) can be calculated from the present worth O&M costs for a discount rate of 7 percent and a period of performance of 30 years (PW(7%,30)) using an adjustment factor (F(X%,Y)):

$$PW(X\%,Y) = F(X\%,Y) * PW(7\%,30)$$

Table 5-2 presents values of F(X%,Y) for combinations of discount rates of 0, 3, 5, 7, and 10 percent and periods of performance of 30, 50, and 100 years. For example, the estimated present worth cost of O&M for a discount rate of 5 percent and a period of performance of 50 years (PW(5%,50)) would be approximately 50 percent greater than the cost for a discount rate of 7 percent and a period of performance of 30 years (PW(7%,30)).

5.2.7.5 Cost Ranges

A range of costs has been estimated for each alternative to explore cost uncertainties associated with sludge disposal and cover construction. The low end of the range ("base" cost) was estimated assuming onsite sludge disposal. The high end of the range ("base plus incremental" cost) was estimated assuming offsite sludge disposal at the Richland facility and increased costs for construction of protective covers (increased cover thickness or longer material haul distances).

5.2.7.6 Accuracy of Cost Estimates

Consistent with RI/FS guidance (EPA 1988), the goal of the FS cost estimate is to achieve an accuracy of approximately +50 percent to –30 percent[10] on the present worth cost of each alternative. The FS cost estimate should indicate if it is unrealistic to achieve this level of accuracy given the available information.

[10] There should be a high probability that the true or actual cost (which is uncertain) would not exceed the estimated cost by more than 50 percent or be less than the estimated cost by more than 30 percent.

In this FS, a range of estimated costs is provided for each alternative. As described above, the range is based on uncertainties with respect to the cost of constructing protective covers and disposing of water treatment residuals. The stated ranges do not take into account the accuracy of the estimate. In other words, if the stated cost range is $10,000,000 to $20,000,000, the cost range including the accuracy of the estimate could be as large as $7,000,000 to $30,000,000.

5.3 INDIVIDUAL ANALYSIS OF ALTERNATIVES

This section describes each of the retained alternatives and the individual analysis of the alternatives using the seven FS evaluation criteria. Table 5-3 presents an overview summary of the remedial alternatives retained for detailed analysis.

The alternatives are not mutually exclusive choices and do not limit the choice of a remedy, which is not selected until the ROD. Thus, a preferred alternative as developed in the Proposed Plan, or the selected remedy as developed in the ROD, can mix the elements of the various alternatives developed in the FS, refine or modify those elements, or add to them. While the FS supplies information for helping select a remedy, information supplementing the FS may be incorporated into the remedy selection process at any time.

The retained alternatives that are analyzed in this section are a subset of the candidate alternatives developed for cleanup of the site. The candidate alternatives were screened based on effectiveness, implementability, and cost, as described in Section 4. As a result of this screening, eight alternatives were retained for detailed analysis:

- Alternative 1. No Action
- Alternative 2b. Institutional Controls, Monitoring, and Continued Existing Water Treatment
- Alternative 3c. Consolidation and Containment of Surface and Stockpiled Materials and Water Collection and Ex-Situ Treatment
- Alternative 3d. Consolidation and Containment of Surface and Stockpiled Materials and In-Situ Groundwater and Pit Water Treatment
- Alternative 4d. Amendment and Consolidation of Surface and Stockpiled Materials in Pits (Partial Backfill) and Water Treatment in Pit 3
- Alternative 4e. Consolidation of Surface and Stockpiled Materials in Unlined Pits (Partial Backfill) with Pit Drains and Ex-Situ Water Treatment
- Alternative 5a. Consolidation of Surface and Stockpiled Materials in Open Pits (Complete Backfill) with Pit Drains and Ex-Situ Water Treatment

- Alternative 5c. Excavation of Backfilled Pits, Consolidation of Surface and Stockpiled Materials in Open Pits (Complete Backfill) with Pit Drains and Ex-Situ Water Treatment

5.3.1 Common Elements

Elements common to two or more alternatives are described in this section. The common elements include institutional controls, monitoring, cover systems, water treatment and sludge disposal, the PCP, and stormwater management.

5.3.1.1 Institutional and Access Controls

Each of the alternatives, except the no-action alternative, includes institutional controls to prohibit residential use in areas where ore, protore, or waste rock would remain after remedy implementation, as well as areas needed to operate a water treatment system and, if applicable, for onsite sludge disposal. Under Alternatives 2b, 3c, 3d, 4d, and 4e, the non-residential use area would encompass nearly the entire MA. Under Alternative 5a, the non-residential use area would include Pit 3, Pit 4, and the backfilled pits area. Under Alternative 5c, the non-residential use area would include Pit 3 and Pit 4. These use restrictions would have to be maintained in perpetuity to limit exposure to COCs, particularly radon in air, and to protect the integrity of containment systems.

Each alternative includes institutional controls to prohibit development of affected groundwater or surface water for drinking or use in sweat lodges. This prohibition would remain in effect until the results of monitoring demonstrate that COCs in groundwater or surface water have been reduced to levels that are safe for consumption or use for ceremonial or spiritual purposes or have been reduced to background levels, whichever is higher. It is anticipated that an extended recovery period would be needed under any of the alternatives before affected groundwater within the MA or the three drainages south of the MA could be safely used for these purposes.

Each alternative, except the no-action alternative and Alternatives 5a and 5c, includes access controls (e.g., fences). Access controls would be used where unrestricted access could result in direct exposure to contaminated surface materials at unacceptable levels. Under Alternative 2b, access to the MA would be restricted. Under Alternatives 3c and 3d, access to the open pits would be restricted. Under Alternatives 4d and 4e, access to the open pit highwalls would be restricted. In addition, Alternatives 3c, 3d, 4d, 4e, 5a, and 5c include access controls (e.g., boulder barriers) around areas of protective covers to limit the potential for damage to the covers (e.g., from off-road vehicle traffic).

Each of the alternatives would include information programs (e.g., signs and advisories) to inform users about potential risks associated with exposure to COCs in surface material, surface water, sediments, and plant and animal tissue.

A summary of the institutional and access controls included under each of the alternatives is presented in Table 5-4.

5.3.1.2 Monitoring and Five-Year Reviews

Each of the alternatives would incorporate a site-wide, long-term monitoring program that would be designed to detect trends in environmental conditions within the MA, the drainages, and Blue Creek, including its delta in the Spokane Arm of Lake Roosevelt. Data collected under the monitoring program also would be used to prepare the five-year reviews that are required under CERCLA when contamination is left on site above levels that allow unrestricted use and unlimited access. The program would include monitoring of surface water, groundwater, sediment, and biological resources. In addition, monitoring would be conducted to evaluate water treatment system processes and discharge, cover integrity, and mass movement of any steeply sloped areas that may remain after remedy implementation.

The monitoring data and the five-year reviews would be used to provide an ongoing assessment of the progress of the remedy toward meeting RAOs. In particular, the extent of remedial actions and the recovery time frames needed to achieve RAOs for MAA surface water, groundwater, sediment, and biological resources are uncertain and would be periodically reassessed. The following three-step assessment strategy would be used:

1. Collect and analyze monitoring data and other available information
2. Update the understanding of the site conditions and compare the monitoring results to RAOs
3. Decide what improvements, if any, are appropriate to modify the monitoring program

If periodic reviews find that a remedy is not protective of human health and of the environment (or making necessary progress towards protectiveness), CERCLA provides for amendments of the selected remedy.

5.3.1.3 Cover Systems

Cover systems to contain ore, protore, and waste rock within the MA are included under Alternatives 3c, 3d, 4d, 4e, 5a, and 5c. Cover systems would be used to achieve several objectives, including:

- Eliminating the direct exposure pathway for humans and ecological receptors to COCs
- Reducing radon flux to comply with potentially relevant and appropriate requirements under the UMTRCA (40 CFR 192.02) and NESHAPs (40 CFR 61)

- Reducing external radiation exposures to acceptable levels
- Reducing percolation of surface water and diffusion of oxygen through potentially reactive waste materials (i.e., mine wastes that are may leach contaminants)
- Supporting vegetation and limiting uptake of COCs through plant roots
- Minimizing long-term O&M, to the extent practical

The design of the cover system would be determined during the remedial design phase. The availability of soil suitable for cover construction will be an important factor in the cover design. In this FS, various conceptual cover designs were examined to evaluate the potential range in cover cost and performance including:

- A homogeneous "evapotranspiration" cover
- A multi-layer cover that includes low-permeability clay and/or geosynthetic elements
- A two-layer cover (an evapotranspiration cover over a layer of waste rock) for use in areas of ore and protore

Figure 5-1 presents conceptual cross sections for the three cover types evaluated. The details of the evaluations with respect to reducing radon flux, water percolation, and external radiation exposure rates are presented in Appendix B. A summary of cover material requirements for various conceptual cover designs is presented in Table 5-5.

For FS analysis, the evapotranspiration cover design was used to evaluate the performance (including reductions in radon flux, water percolation, and external radiation exposure rates) and cost of each cleanup alternative, except Alternative 5c (a multi-layer cover consisting of an FML) and 2.7 feet of soil was evaluated under Alternative 5c). A "thick cover" was evaluated for site waste materials with generally high radon emanation and relatively high reactivity (generally ore and protore), and a "thin cover" was evaluated for materials with generally low radon emanation and relatively low reactivity (generally waste rock). In addition, a range of thin and thick cover thicknesses was developed, based on the suitability of potentially available cover materials, to evaluate the cost of constructing evapotranspiration covers. Use of an evapotranspiration cover design in the FS analysis does not preclude the use of any other cover design for remedial actions at the site.

The covers were analyzed using analytical radon flux calculations (NRC 1989) and the RAECOM computer code (Rogers and Nielson 1984). The radon source was characterized using the averages of measured values of radon flux from ore and protore materials (140 $pCi/m^2/s$) and waste rock (32 $pCi/m^2/s$) (EPA 2005). The results of these analyses for the "thick cover" and "thin cover" are presented in Table 5-6. Based on these analyses, the covers would meet the UMTRCA and NESHAPs standard (areawide average radon flux not to exceed 20 $pCi/m^2/s$, averaged over a period of at least one year).

Percolation through covers was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) version 3.07 model (Schroeder, et al. 1994). The results of these analyses for the "thick cover" and "thin cover" are presented in Table 5-6. Based on these analyses, the covers would reduce percolation of surface water by approximately 72 to 78 percent compared to current conditions.

Attenuation of external gamma radiation by soil covers was evaluated using values of the fraction of unshielded exposure rate to depth for various depths of overburden (packed earth) developed by Schiager (1974), as reported by Shepard Miller, Inc. (1996). Based on this analysis, the covers would reduce external gamma radiation exposure rates to less than the estimated background gamma exposure rate of 22.3 uR/hr. The analysis is described in Appendix B.

The FML cover would further limit water percolation and radon flux compared to an evapotranspiration cover. It is estimated that the FML cover would reduce percolation of surface water by 95 percent or more compared to current conditions. However, over the long term, the FML would be subject to deterioration, and reducing percolation and radon flux would primarily be accomplished by the soil cover.

There are several potential sources of material that could be used for cover construction. Information about some of these potential sources is presented in a preliminary borrow material evaluation (URS 2000) and is summarized below.

- ***Onsite waste rock.*** Waste rock with suitable gradation and COC concentrations could be used in a subsurface cover layer to attenuate radon and external radiation from materials with high levels of radionuclides (e.g., ore and protore). The Hillside Dump is a potential source of waste rock that could be used in a subsurface cover layer.
- ***Decomposed quartz monzonite.*** This material is present within and west of the MA. This material would contain acceptable levels of COCs; however, the available volume and suitability for use as a radon or water percolation barrier has not been evaluated. Assuming extensive processing would not be necessary, this material probably would be less expensive than cover materials used to develop cost estimates in this FS. To the extent this material could be used, costs and community impacts associated with hauling materials would be reduced compared to FS assumptions.
- ***Sand Creek.*** These materials are primarily terrace deposits consisting of sand with relatively small percentages of fines. The material would likely have relatively poor water retention properties. This potential source is relatively close to the site, and the material could be hauled to site with relatively few traffic impacts. This is the assumed source of the "less suitable" materials (i.e., upper range of cover thickness and cost) evaluated in this FS. For estimating costs, a round-trip haul distance of 15

miles was used. It may be possible to improve the performance of this material by amending it with fine-grained material.

- ***Sherwood mine site.*** There are an estimated 169,000 cy of clayey material stockpiled on site that may be available. The best existing haul road goes through Wellpinit and is a one-way distance of approximately 17 miles to Midnite Mine.
- ***Farmland north of Davenport area.*** These materials are classified as SCS Broadax, and consist of silts and clays. There is potentially a large volume of material; however, the sources are not currently developed, and the availability of material is uncertain. This area is located approximately 28 miles from the site. This is the assumed source of the "more suitable" materials (i.e., lower range of cover thickness and cost) evaluated in this FS. For estimating costs, a round-trip haul distance of 56 miles was used.
- ***Loon Lake and Long Prairie area.*** There are former clay pits in the area and potentially large volumes of material. However, there is no current materials production, and the availability of material is unknown. The area is located 30 to 40 miles from the site. Soils are classified as SCS Martella silt loam and Bernhill silt loam.
- ***Existing commercial sources.*** Mutual Materials Co., Mica, Washington is the closest existing commercial source of clay. The vendor has at least 250,000 cy of clay and is located approximately 70 miles from the site. Inland Northwest, Springdale, Washington, has 26 acres of overburden that is 3 to 4 feet thick and may be a source of suitable material. Springdale is approximately 27 miles from the site.

Cover materials may be amended with organic material, or a layer of topsoil may be placed to support revegetation. The cost estimates included in this FS assume 8 inches of imported topsoil to facilitate revegetation. The ultimate goal of revegetation would be establishment of a native plant community that would maximize evapotranspiration and minimize O&M.

5.3.1.4 Water Treatment and Sludge Disposal

Each alternative, except the no-action alternative, includes collection and treatment of impacted site water, to the extent treatment would be needed after source control measures have been implemented. Under Alternatives 2b, 3c, 4e, 5a, and 5c, water treatment would be accomplished using active ex-situ treatment, as is currently conducted at the site. Under Alternatives 3d and 4d, water treatment would be conducted in-situ, as described in Sections 5.3.5 and 5.3.6, and ex-situ treatment would only be conducted if the effluent from the in-situ treatment system is not suitable for discharge. Based on available information, it is assumed that pit water treated in-situ under Alternative 3d would require further active water treatment prior to discharge. Sufficient information is not available to evaluate whether further treatment would be required under

Alternative 4d. Estimated costs for Alternative 4d were developed assuming no further treatment is necessary and assuming further treatment of all water is necessary.

At this time, the extent of future water treatment is not known; however, it is anticipated that water treatment would be required to some extent for the foreseeable future under each alternative. Appendix C presents the methods used to estimate current and future water treatment requirements under each alternative. These estimates were used in the FS to evaluate the performance and cost of the alternatives. While the FS shows estimated reductions in the volume of water needing treatment (and residuals volumes associated with water treatment), at this time the FS alternatives and cost estimates assume that the water treatment process and the characteristics of residuals are not changed.

The existing water collection system includes collection of contaminated seep water at the southern perimeter of the MA. This water and contaminated water collected in the site surface water management system is conveyed to and temporarily stored in Pit 3. Water in Pit 3 and Pit 4 is treated in the onsite water treatment system. A minimum water level is maintained in the pits to prevent contaminated pit sediments from drying and being transported as airborne dust. Figure 5-2 shows a schematic of the existing water management system.

The existing water treatment system is located on the southeast side of the MA and is licensed by the DOH. The treatment process consists of adding barium chloride to the water to precipitate radium, and adding lime to raise the pH and precipitate other metals and radionuclides in a sludge. Following sludge-thickening and clarification, the treated water is reacidified, filtered to remove suspended solids, and discharged to the Eastern Drainage. The sludge is dewatered using centrifugation and trucked to the Dawn Mining Company mill in Ford, Washington, where it is disposed of in Tailings Disposal Area (TDA) 4.

The sludge consists primarily of aluminum, calcium, magnesium, and manganese hydroxides, and contains approximately 1 to 2 percent uranium on a dry weight basis. The sludge does not have hazardous characteristics and is not a RCRA hazardous waste.

The plant currently operates four days per week, 24 hours per day, typically beginning in April and continuing until the water levels in the pits have been drawn down. Currently, the treatment plant does not operate during the winter months due to adverse effects of freezing temperatures on plant operations and the hazards associated with transporting sludge on the steep mine haul road when it is icy. DOH does not currently permit stockpiling of sludge on site.

Historic Midnite Mine water treatment data, including days of plant operation, volumes of water treated, and sludge generated, are presented in Table 2-17. These data show a large reduction in the volumes of water treated and sludge generated in 2001, 2002, and 2003 compared to prior years. This reduction is largely related to water level management in the open pits. From 1993 to 2000, the annual water treatment totals include not only the seep and runoff water and

groundwater inflow collected during that year, but an additional amount to reduce the volume of water accumulated in the pits prior to 1993. Recent operations have been able to keep pace with the annual accumulation of seeps, runoff, and groundwater inflow.

The NPDES permit limits for the treatment system effluent have been established for uranium, radium, manganese, cadmium, copper, and zinc. The treatment system has consistently met the NPDES permit limits for of all these constituents. In addition, based on available NPDES monitoring results, the effluent also meets Clean Water Act (CWA) national recommended water quality criteria.

For the selected remedy, new discharge limits will need to be established for the treatment system effluent. These limits will be based on the standards established by the Tribe's Surface Water Quality Standards Resolution to the extent they are determined to be applicable or relevant and appropriate and are not subject to a waiver pursuant to 40 CFR 300.430(f)(1)(ii)(C). The concentrations of some constituents, including uranium, manganese, and sulfate, are typically higher in the effluent than the Tribal water quality standards and background concentrations.

Disposal of sludge at the Dawn Mill will not be available indefinitely. The mill is undergoing closure and will be unable to accept sludge once placement of a cover over TDA 4 begins, unless an interim cover is employed that allows continued use of a portion of TDA 4. If an interim cover is used, sludge disposal would be possible until a year before construction of the final cover. The start date for placement of either an interim or final cover is dependent on the evaporation of liquids in evaporation ponds at the mill, but could be as soon as 2006 (Stoffel 2003). If an interim cover is used, the current license would allow continued sludge disposal until 2008. Sludge disposal beyond 2008 would be subject to regulatory acceptance, and beyond 2011 would be unlikely, as it could impede completion of final closure (Lopez 2005). In summary, sludge disposal under the existing approval may be possible until 2011. For this reason, the Midnite Mine FS assumes that water treatment sludge will be disposed of at the Dawn Mill until closure of TDA 4 and that, following closure of the Dawn Mill, sludge will be disposed of either off site or in an engineered disposal facility on site.

If onsite disposal of the sludge is used after closure of TDA 4, an onsite disposal area would need to comply with the substantive requirements of the Spokane Tribe of Indians HSCA Resolution 2004-85, December 2003, that are determined to be applicable or relevant and appropriate, unless waived. For FS analysis, it is assumed the sludge would be dewatered and solidified prior to placement in the onsite repository. An onsite disposal area would be constructed to the standards contained in RCRA Subtitle C and NRC regulations for Class A waste (10 CFR 61 Subparts C and D) that are determined to be relevant and appropriate. For FS analysis, it is assumed the disposal area would include a bottom liner consisting of a geosynthetic clay liner (GCL) and an FML, and final closure would include placement of a low-permeability, composite cap.

If offsite disposal of sludge is used after closure of TDA 4, it is anticipated that the sludge would be classified as Class A low-level radioactive waste (LLRW). In this case, the sludge would be subject to the limitations under compacts between states for disposal of low-level radioactive waste and would have to be disposed of at the licensed commercial facility in Richland, Washington, unless approval for out-of-state disposal is obtained from the Northwest Interstate Compact. To date, out-of-state disposal of LLRW has not been approved by the Northwest Interstate Compact (Hallisy 2004). Therefore, offsite disposal at the Richland facility is evaluated in this FS. The facility is located approximately 200 driving miles from the site.

The Richland facility has restrictions on the water content of waste it can accept, so at a minimum, further dewatering of the sludge would be required prior to disposal. In addition, stabilization or solidification would be required if the dewatered sludge would form more than de minimis amounts of free liquids during transport. The current treatment system, which includes centrifugation, produces a sludge that contains approximately 15 percent solids by weight (SMI 1996). Using a plate and frame filter press, it is estimated the sludge could be dewatered to 40 to 50 percent solids by weight. For this FS, it is assumed sludge would be dewatered using a plate-and-frame filter press and solidified. The estimated unit cost for disposal of sludge at the Richland facility is described in Appendix D.

An EIS was recently published for the Richland facility (DOH 2004). Based on a risk assessment conducted for the EIS, DOH intends to limit future disposal of uranium^{238} in the facility to a total of approximately 4.7 Curies over the life of the facility. DOH has also indicated that disposal of more than 4.7 Curies of uranium^{238} could be permitted if it can be demonstrated to the satisfaction of DOH that further disposal could be done in a manner that is protective. If the uranium^{238} capacity of the facility is exhausted in the future, the Envirocare low-level waste disposal facility in Clive, Utah is a potential alternate disposal site for the sludge. Approval from the Northwest Interstate Compact would be required for disposal at the Envirocare facility. Based on discussions with Ecology, it is likely approval would be granted if the Richland facility is unable to accept the sludge (Garner 2004).

A water treatment option evaluated by the Bureau of Mines is pretreatment of the water to remove uranium and radium (Schultze, et al. undated). The purpose of pretreatment would be to remove radionuclides so that the sludge resulting from the current chemical precipitation process would not be low-level radioactive waste. In this case, offsite sludge disposal options in addition to the Richland facility could be available, and the sludge potentially could be disposed of at lower cost. DOH regulations (WAC 246-232-120) limit the amount of radium^{226} that can be disposed of in a solid waste landfill to 0.1 microCuries (equal to 0.1 micrograms). Even with pretreatment, the limitation for radium would be exceeded in a relatively short time. Consequently, disposal in a solid waste landfill in the State of Washington would not be a potential option. Depending on the characteristics of the sludge, it might meet the waste acceptance criteria for disposal in the facility operated by U.S. Ecology in Grandview, Idaho. A preliminary evaluation of the cost to conduct pretreatment (ion exchange to remove uranium)

and dispose of the chemical precipitation sludge at the Grandview facility is presented in Section 5.5.

The Tribe's surface water quality standards include a sulfate standard of 250 mg/L for protection of human health for direct contact with water resulting from spiritual or ceremonial uses. The Tribe's surface water quality standards currently do not provide for use of a mixing zone. Thus, if this standard is determined by EPA to be applicable or relevant and appropriate, the sulfate concentration in any water discharged to waters of the Tribe would need to less than or equal to 250 mg/L. The existing WTP is not designed to remove sulfate. Based on available measurements of the effluent and water in the outfall pond, sulfate concentrations in the WTP effluent range from 1,650 to 2,600 mg/L. Modifications to the WTP would be necessary to reduce sulfate concentrations in the effluent, and modifications necessary to achieve 250 mg/L in the effluent could be significant. Any modifications would result in treatment residuals containing sulfate that would require proper management. Because of the relatively large amounts of sulfate in the water that is treated in the WTP, the volume of residuals produced per unit volume of water treated would increase compared to the volume of sludge currently produced. EPA is working with the Tribe to determine limits for sulfate in the WTP discharge. A preliminary evaluation of the cost to reduce the concentration of sulfate in the WTP effluent to 250 mg/L is presented in Section 5.5.

5.3.1.5 Pollution Control Pond

Under alternatives that include regrading of the South Spoils (Alternatives 3c, 3d, 4d, and 4e), waste rock may be placed in the area currently occupied by the PCP. The PCP would no longer exist after implementation of any of these alternatives, and, to the extent seeps continued to exist in the Central Drainage after implementation of the remedy, the seeps would be collected in a system similar to that currently used to collect the seeps in the Western Drainage. Subsequent routing of the seep water for treatment varies under each of these alternatives and is described in the following sections under each alternative. Additional pump stations would be constructed, as needed, to convey the seep water.

5.3.1.6 Stormwater Management System

Alternatives 3c, 3d, 4d, 4e, 5a, and 5c each include a stormwater management system that would promote runoff, reduce infiltration, and limit erosion and offsite migration of mining waste materials. The stormwater management system would include channels, drains, and settling ponds that would be integrated with the cover systems to intercept clean surface water and convey it to the drainages, where it would be discharged immediately downstream of the existing seep collection systems. The stormwater management system would supplement existing flows in the drainages with clean water. The system would be designed to accommodate the 100-year, 24-hour storm event. Under Alternatives 3c, 3d, 4d, and 4e, the stormwater management system would collect runoff from the entire MA. Under Alternative 5a, the stormwater management

system would collect runoff from the areas above Pits 3 and 4, which would be backfilled, and the existing backfilled pits. Under Alternative 5c, the stormwater management system would collect runoff from the areas above backfilled Pits 3 and 4, which would be backfilled.

Alternative 2b includes the existing stormwater management system at the site. This system routes runoff water from uncovered areas of the MA into Pit 3, Pit 4, and the PCP. The collected water is subsequently treated in the WTP. Runoff from covered areas of the South Spoils is collected together with runoff water from unaffected areas west of the MA and discharged to the Western Drainage (EPA 2002a).

5.3.2 Alternative 1 (No Action)

5.3.2.1 Description

Alternative 1 includes no actions to control exposures of humans and ecological receptors to contaminants. Under Alternative 1, operation of the existing water collection and treatment system would be discontinued. Maintenance of other engineered measures currently in place, such as revegetated waste materials and stormwater management systems, also would be discontinued. Consideration of the no action alternative is required by the NCP.

5.3.2.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. Under Alternative 1, no measures are included to reduce exposure to COCs in surface materials, external radiation, and airborne radon. As a result, risks due to ingestion of surface materials, exposure to external radiation, and inhalation of radon would exceed protective levels for humans and other terrestrial animals, as described in Section 1.2.

Surface Water and Sediment in Open Pits. Under Alternative 1, no measures are included to reduce exposure to COCs in open pit water and sediments. As a result, risks due to ingestion of COCs in pit water and sediments would exceed protective levels for humans and other ecological receptors, as described in Section 1.2. Pumping of water from the pits would be discontinued, and the water levels in the pits would rise. As a result, some potential for release of contaminated water from the pits would exist, particularly if water levels rose above the elevation of the bedrock surface adjacent to the pits.

Groundwater Within the MA. Under Alternative 1, no measures are included to reduce potential future human exposures to groundwater. In addition, no measures are included to reduce transport of contaminants from groundwater to surface water. Because collection and treatment of the seeps would be discontinued under Alternative 1, there would be a large increase in the transport of contaminants from groundwater to surface water.

Surface Water and Groundwater in Mine Drainages and Blue Creek. Under Alternative 1, future surface water quality would deteriorate as a result of discontinuing water collection and treatment. To help evaluate the effect of discontinuing water treatment on future surface water quality, the current uranium load removal by the treatment system has been estimated (Appendix F). It is estimated that the uranium load in the Eastern Drainage is approximately 1 percent of the uranium load removed by the WTP. Thus, concentrations of uranium in surface water, a risk driver for ingestion of surface water, could increase by up to two orders of magnitude under Alternative 1. Risks to humans and aquatic organisms from exposure to COCs in surface water, which exceed protective levels under current conditions, would increase under Alternative 1.

Currently, the estimated average uranium load in the Eastern Drainage, based on historic (1995 to 2002) data, is approximately 100 pounds per year. The estimated average uranium load under Alternative 1 could increase to as high as 10,000 pounds per year (Appendix F).

Groundwater quality likely would deteriorate under Alternative 1. Currently, water levels in the pits are maintained at levels that limit outflow of contaminated pit water from the pits to groundwater. Under Alternative 1, no control would be exercised over pit water levels, and the levels could rise to levels that result in increased outflow of contaminated pit water to groundwater. In addition, contaminated seep and runoff water would be discharged to the drainages without treatment. In losing reaches of the drainages, some of this water would discharge into the alluvial aquifer, resulting in reduced groundwater quality in these areas. As a result of these effects, risks to humans from exposure to COCs in groundwater would continue to exceed protective levels under Alternative 1.

Sediment in Mine Drainages and Blue Creek. No measures are included under Alternative 1 to control erosion and transport of contaminated MA surface material. As a result, sediment quality in MAA drainages and Blue Creek would deteriorate over time as stormwater erodes contaminated MA surface material and deposits it in the MAA drainages and Blue Creek. Concentrations of COCs in sediment and plants, which exceed protective levels for humans and aquatic organisms under current conditions, would increase.

Haul Roads. Under Alternative 1, no action would be taken to reduce exposure to surface materials in the haul roads and adjacent impacted areas, and exposures would remain similar to current conditions for the foreseeable future. Under current conditions, human health risks due to exposure to surface materials in the haul roads and adjacent impacted areas exceed protective levels.

Plant and Animal Tissue. Based on the HHRA, measured concentrations of COCs in plants and modeled concentrations of COCs in animal tissue pose an unacceptable risk from subsistence use. Under Alternative 1, no actions would be taken to reduce uptake of COCs by plants or animals or to reduce human exposure to plant or animal tissue.

Summary. In summary, Alternative 1 does not meet the threshold criterion of protection of human health and the environment.

5.3.2.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium isotopes and lead^{210} exceed the Tribal water quality standard (for these contaminants, background) for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses. Under Alternative 1, loads of these constituents discharged to Blue Creek and the drainages would increase, and exceedances of potential ARARs for protection of human health would continue or increase for the foreseeable future.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Under Alternative 1, loads of heavy metals discharged from the Eastern Drainage to Blue Creek would increase, and exceedances of potential ARARs for protection of aquatic life would be likely to occur. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed ARARs for protection of aquatic life at one or more locations. Under Alternative 1, exceedances of these potential ARARs would continue or increase for the foreseeable future.

Under Alternative 1, seep and runoff water containing COC concentrations that do not comply with potential ARARs would be discharged to the drainages. Water in the drainages and Blue Creek would continue to contain COCs at concentrations that exceed potential ARARs for a period of centuries to millennia.

Groundwater. A comparison of concentrations of COCs in groundwater measured during the RI to potential ARARs for protection of human health is presented in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent

to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations. Under Alternative 1, concentrations of COCs in groundwater would probably increase compared to current conditions and the extent of the plume could increase. Therefore, Alternative 1 would not comply with potential groundwater ARARs.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and adjacent to the haul roads, concentrations of lead, radium, and uranium exceed potential ARARs. Under Alternative 1, concentrations of COCs in surface materials would continue to exceed potential ARARs for the foreseeable future. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 1, concentrations of COCs in sediment would continue to exceed potential ARARs for the foreseeable future.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Radon flux within the MA would not comply with the 40 CFR 61 standard.

Waste Management. Because no waste disposal would be conducted under Alternative 1, there would be no potential waste management ARARs.

Summary. In summary, Alternative 1 would not comply with ARARs for surface water, groundwater, surface materials, sediment, and air.

5.3.2.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 1 to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, and air under Alternative 1 are evaluated in this section.

Surface Water and Groundwater. Risks to humans and ecological receptors from exposure to surface water, which exceed protective levels under current conditions, would increase after collection and treatment of contaminated site water is discontinued under Alternative 1. Historically, the uranium load in the Eastern Drainage is 1 to 3 percent of the uranium load removed by the WTP. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, could increase by up to two orders of magnitude under Alternative 1.

For ingestion of surface water as drinking water (including the seeps, which are collected and treated under current conditions), the HHRA estimated non-cancer hazards ranging from 22 (Blue Creek) to 98 (MAA drainages) and cancer risks ranging from 8 in 10,000 (Blue Creek) to 1 in 10 (MAA drainages). For inhalation of surface water vapor during sweat lodge use (including the seeps, which are collected and treated under current conditions), the HHRA estimated non-cancer hazards ranging from 236 (Blue Creek) to 9,767 (MAA drainages) and cancer risks ranging from 2 in 1,000 (Blue Creek) to 8 in 10 (MAA drainages). Under Alternative 1, risks and hazards resulting from ingestion of surface water and inhalation of water vapor in the MAA drainages could increase to these levels, or higher, after collection and treatment of contaminated seep and runoff water are discontinued. Risks and hazards resulting from ingestion of surface water and inhalation of water vapor in Blue Creek would increase from these levels under Alternative 1.

Sediment. Contaminated site water would no longer be collected for sediment removal under Alternative 1. As a result, risks to humans and ecological receptors from exposure to sediment in the mine drainages and Blue Creek, which exceed protective levels under current conditions, would increase under Alternative 1. Under current conditions, the estimated non-cancer hazards and cancer risk from exposure to COCs in drainage sediments are 8 (adult) to 31 (child) and 9 in 10,000, respectively. The estimated non-cancer hazards from exposure to COCs in Blue Creek sediments are 0.6 (adult) to 2 (child). No carcinogens were identified as COPCs for Blue Creek sediments.

Risks from exposure to sediments in the open pits would continue unabated under Alternative 1. Currently, the estimated non-cancer hazards and cancer risk from exposure to COCs in the open pits are 6 (adult) to 25 (child) and 1 in 1,000, respectively.

Surface Materials. Under Alternative 1, no further source containment measures would be implemented. As a result, risks to human and ecological receptors from exposure to external radiation and COCs in surface materials in the MA and the haul roads would remain at current levels. For MA surface materials, the estimated cancer risk from exposure to external radiation is 1 in 100, and the estimated non-cancer hazard and cancer risk from exposure to COCs in

surface materials are 6 (adult) to 28 (infant) and 3 in 1,000, respectively.[11] For the haul roads, the estimated non-cancer hazard and cancer risk from exposure to COCs in surface materials are 6 (adult) to 23 (child) and 2 in 1,000, respectively.

Air. Risks to humans from exposure to airborne radon exceed protective levels under current conditions. The HHRA estimated risks of 6 in 1,000 for outdoor air and 2 in 10 for indoor air under current conditions. Under Alternative 1, these risks would continue unabated.

Adequacy and Reliability of Controls. There are no controls under Alternative 1; therefore, the adequacy and reliability of controls was not evaluated.

5.3.2.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

There would be no reduction of toxicity, mobility, or volume through treatment under Alternative 1.

5.3.2.6 Short-Term Effectiveness

Alternative 1 includes no response actions; therefore, there would be no effects on human health and the environment during implementation of the remedy. However, none of the RAOs would be achieved within the foreseeable future.

5.3.2.7 Implementability

Because Alternative 1 includes no actions, it is not evaluated for implementability.

5.3.2.8 Cost

Alternative 1 includes no actions, hence, there would be no cost.

5.3.3 Alternative 2b (Institutional Controls and Water Treatment)

5.3.3.1 Description

The primary elements of Alternative 2b include:

- Continued operation and maintenance of the existing WTP
- Additional sludge dewatering and sludge solidification
- Continued maintenance of existing covered areas and stormwater and seep water collection systems

[11] Cancer risks and non-cancer hazards for a residential scenario; a non-residential surface material exposure scenario was not evaluated for the MA.

- Institutional controls, including use restrictions and information programs
- Access controls (a fence around the MA)
- Long-term monitoring and 5-year reviews

An overview summary of the elements of Alternative 2b is presented in Table 5-3. A summary of institutional controls included under Alternative 2b is presented in Table 5-4.

Alternative 2b represents current conditions at the site, with institutional controls used to limit exposure of humans and, to a limited extent, ecological receptors to site contaminants. No new removal, containment, or treatment actions would be implemented; however, Alternative 2b includes continued O&M of the existing water collection and treatment system. A long-term monitoring program would be implemented to detect trends in environmental conditions within the MA, the drainages, and Blue Creek, including its delta in the Spokane Arm of Lake Roosevelt.

Under Alternative 2b, a fence would surround the entire MA to limit access. Gates and warning signage would be used to limit access to the haul roads. Institutional controls would prohibit future development of the MA and other mining-affected areas for residential or industrial use. In the MA and other areas of mining-affected groundwater, institutional controls would prohibit installation of groundwater wells.

Warning signage would be placed at key locations within the MAA drainages to reduce exposure to contaminated surface water, sediments, and plants in these drainages. Warning signage and informational programs would be used to inform potential users of the risks associated with recreating, practicing subsistence, or otherwise consuming plants, game animals, or water from mining-affected areas. EPA would coordinate with the Tribe to develop and implement the education and institutional controls program.

Under Alternative 2b, operation of the existing water collection and treatment system and maintenance of other measures currently in place would be continued. The existing water collection and treatment system is described in Section 5.3.1.4. Contaminated seep and runoff water would continue to be stored in Pit 3, and water treatment would continue on a seasonal basis. Alternative 2b includes maintenance of the water collection system and the WTP, as well as replacement of the WTP at the end of its service life. Sludge generated by the treatment system would continue to be disposed of at the Ford facility until closure of TDA 4 (between 2006 and 2011). An alternate sludge disposal method would be needed after closure of TDA 4. For this FS, costs have been developed for both onsite and offsite sludge disposal.

Onsite and offsite sludge disposal are described in Section 5.3.1.4. Under both disposal options, it is assumed for FS analysis that the sludge would be further dewatered using a frame filter press and solidified. A potential location for an onsite sludge disposal area has not been identified at

this time. If onsite disposal is used, it is assumed a sludge disposal area would be constructed in the southwest part of the site in the vicinity of the former mine offices. For FS analysis, it is assumed requirements for onsite disposal would include additional sludge dewatering and solidification, a basal liner, and a low-permeability, composite cap.

For FS analysis, an estimate of future treatment requirements was made, as described in Appendix C. Under Alternative 2b, the estimated average future water treatment rate is 80 million gallons per year, and the estimated average future sludge generation is 470 tons per year (12,000 cubic feet per year) after dewatering.

If onsite disposal is used, it is assumed for FS analysis that the facility would be constructed with a 100-year capacity. Based on an estimated volumetric sludge generation rate of 12,000 cubic feet per year, the required disposal facility capacity would be 1,200,000 cubic feet (44,000 cy). For an assumed average waste thickness of 20 feet, the disposal facility footprint would be approximately 2 acres. Because the need to treat water under Alternative 2b would continue indefinitely, water treatment and sludge disposal options would need to be reevaluated before the sludge disposal capacity was exhausted.

The South Spoils waste rock pile has side slopes ranging from 1.4:1 to 2.5:1 horizontal to vertical (H:V) with several benches ranging from 60 to 70 feet wide. Portions of the South Spoils were regraded, covered with 8 inches of topsoil, and vegetated by DMC between 1980 and 1982. The reclaimed areas have an overall slope of 2.2H:1V, except for the slopes above the PCP, which are steeper. The Hillside Dump, including the benches, has an overall side slope grade of about 2.9H:1V. Although the Hillside Dump has not been reclaimed, native vegetation, including trees, has moved into the area (SMI 1996).

Slope stability has been evaluated for the South Spoils and Hillside Dump. In all but one case, the computed theoretical static factors of safety for the cross-sections evaluated were 1.3 and greater, and the computed theoretical pseudo-static factors of safety were greater than 1.0. Analysis of the South Spoils slope immediately above the PCP resulted in calculated minimum factors of safety of 1.1 (static) and 0.9 (pseudo-static) for a shallow shear surface. The results indicate a marginal safety level against shallow, surficial-type failure. The open pit highwalls appear to be currently stable and are expected to remain stable (EPA 2002b). Steep slopes are also present on the east face of the Pit 4 Dump. Under Alternative 2b, any slope failures that may occur would be addressed through maintenance, as needed.

For contaminated sediments in the MAA drainages, Alternative 2b would rely on natural recovery to improve sediment quality over time. Stormwater within the MA is currently collected in the surface water management system and conveyed to Pit 3, Pit 4, and the PCP, where contaminated sediment entrained in the stormwater settles out. This water is then conveyed to the WTP for treatment and released to the Eastern Drainage. Runoff from a portion of the western South Spoils that has been previously reclaimed is released to the Western

Drainage without treatment; however, this water contains relatively small loads of contaminated sediment. As a result, the inputs of sediment deposited in the MAA drainages are derived largely from areas that have not been impacted by mining, and the overall quality of sediment in the MAA drainages and Blue Creek is believed to be improving with time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas.

5.3.3.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. An approximately 8-inch thick soil cover has been placed over most of the South Spoils, which reduces exposure to surface materials, external radiation, and radon and reduces erosion of contaminated surface materials in this area. No additional cover materials would be placed over uncovered ore, protore, and waste rock in other areas of the MA under Alternative 2b. As a result, risks due to ingestion of surface materials, exposure to external radiation, and inhalation of radon would exceed protective levels for humans and other terrestrial animals, as described in Section 1.2, if unlimited exposure were allowed. Under Alternative 2b, a fence would be used to limit the exposure of humans and other large animals to MA surface materials. Other animals would potentially be exposed to COCs in surface materials.

Surface Water and Sediment in Open Pits. Under Alternative 2b, the quality of water in Pit 4 would likely remain similar to current conditions for the foreseeable future. The quality of water in Pit 3 would improve somewhat compared to higher water level periods, because the portion of the pit water that consists of the more contaminated seep water would be reduced and the residence time of the water in the pit would be reduced. However, Pit 3 would continue to be used for temporary storage of untreated seep water, and the quality of water in Pit 3 would likely be poorer than in Pit 4 for the foreseeable future. The concentrations of COCs in water in both pits would exceed protective levels, and protection of humans and other larger mammals would be achieved through access restrictions using a fence around the MA. Other animals would potentially be exposed to COCs in surface water and sediment in the open pits.

Groundwater Within the MA. Under Alternative 2b, access and use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. These restrictions would be needed for the foreseeable future. No additional measures are included to reduce transport of contaminants from groundwater to surface water. Collection and treatment of

the seeps would be continued under Alternative 2b, which would continue to greatly reduce the transport of contaminants from groundwater to surface water compared to no action.

Surface Water and Groundwater in Mine Drainages and Blue Creek. Alternative 2b includes continued collection and treatment of contaminated surface water and seep water. To estimate the effectiveness of the existing water collection and treatment system, estimates were made of the loads of uranium removed in the treatment system and loads of uranium discharging in the Eastern Drainage (Appendix F). During the period 1995 through 2002, an estimated average of 12,100 pounds per year of uranium (adjusted for changes in pit water storage) were removed in the water treatment system. During the same period, an estimated average of 110 pounds per year of uranium were discharged in the Eastern Drainage. These estimates indicate that, under current conditions, the uranium load in the Eastern Drainage is approximately 1 percent of the uranium load removed by the WTP.

Although surface water quality in the mine drainages and Blue Creek would be substantially better under Alternative 2b than if collection and treatment were not conducted, surface water would contain COCs at concentrations that exceed background, and use restrictions and information programs would be included to limit human exposures. These restrictions would be needed for the foreseeable future.

Although not currently used as a drinking water source, groundwater in the mine drainages would contain COCs at concentrations that exceed background, and use restrictions would be included that would prohibit the installation of drinking water wells. No COCs have been detected at concentrations exceeding background in groundwater in the Blue Creek drainage.

Sediment in Mine Drainages and Blue Creek. The overall quality of sediment in the mine drainages and Blue Creek should continue to improve over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas. However, the capacity of the existing stormwater management system is unknown, there may be some potential for release of contaminated sediment during large storm events. Concentrations of COCs in sediment would likely exceed protective levels for humans and aquatic organisms for the foreseeable future. Information programs would be used to help limit human exposure to COCs in drainage sediments and plants.

Haul Roads. Under Alternative 2b, gates and warning signage would be used to reduce human exposure to surface materials in the haul roads and adjacent areas. These measures would not reduce exposures of terrestrial animals and plants to surface materials in the haul roads and adjacent areas.

Plant and Animal Tissue. Under Alternative 2b, a fence would be used to limit ingestion of plant and animal tissue by humans within the MA. The fence would reduce uptake of COCs by large animals via ingestion of contaminated surface material, sediment, and surface water within

the MA. No actions would be taken to reduce uptake of COCs by plants or small animals. Information programs would also be implemented to reduce human ingestion of contaminated plant and animal tissue from the MA and MAA, including Blue Creek.

Summary. In summary, Alternative 2b would provide protection of human health by restricting access to the MA and haul roads and using institutional controls to reduce exposures within the MAA, including Blue Creek. These restrictions would be needed for the foreseeable future. It is not anticipated that background concentrations of ecological risk drivers in surface water, surface materials, and sediment would be achieved within the foreseeable future under Alternative 2b. As a result, Alternative 2b might not provide protection of the environment.

5.3.3.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses. Under Alternative 2b, loads of these constituents discharged to Blue Creek and the drainages would remain approximately the same or decrease somewhat, and exceedances of potential ARARs for protection of human health would continue for the foreseeable future.

Currently in Blue Creek, surface water ARARs for protection of aquatic life are not exceeded, although for aluminum and cadmium, the ARAR is background. Under Alternative 2b, loads of contaminants discharged from the Eastern Drainage to Blue Creek would remain approximately the same or decrease somewhat, and exceedances of aquatic life criteria would be unlikely to occur. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations. Under Alternative 2b, exceedances of aquatic life criteria would continue for the foreseeable future.

Under Alternative 2b, the concentrations of some constituents in the WTP effluent, including uranium, manganese, and sulfate, currently exceed Tribal water quality standards and background. Treatability studies would be needed to determine what modifications would need to be made to the WTP to further reduce concentrations of these constituents to meet water quality ARARs. As discussed in Section 5.3.1.4, EPA is continuing to work with the Tribe to

determine discharge requirements for sulfate. A preliminary evaluation of potential costs to treat sulfate to a concentration of 250 mg/L or lower is presented in Section 5.5.

Groundwater. Under Alternative 2b, a WMA would be established that includes the areas in which mine waste is contained (the MA). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations. Under Alternative 2b, future concentrations of contaminants in groundwater would remain approximately the same or decrease somewhat. Therefore, Alternative 2b would not comply with groundwater ARARs for the foreseeable future.

Within the WMA, Alternative 2b includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the four surface material COCs is background. Within the MA and within and adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 2b, concentrations of COCs in surface materials would continue to exceed potential ARARs for the foreseeable future. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 2b, concentration of COCs in sediment would likely improve over time; however, it is likely these concentrations would exceed potential ARARs for the foreseeable future.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Radon flux within the MA would not comply with the 40 CFR 61 standard.

Waste Management. If onsite disposal of treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. In summary, Alternative 2b would not achieve compliance with all ARARs. Institutional controls would be used to provide protection of human health; however, use of institutional controls would not result in compliance with ARARs for surface water, groundwater, surface materials, sediment, or air.

5.3.3.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 2b to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and water treatment sludge at the conclusion of remedial activities under Alternative 2b are evaluated in this section.

Surface Water and Groundwater. Under current conditions, water treatment has resulted in substantial reductions in risks to humans and aquatic organisms compared to no action. Historically, the uranium load in the Eastern Drainage is 1 to 3 percent of the uranium load removed by the WTP, which indicates risks from exposure to uranium, a risk driver for ingestion of surface water, have been reduced by up to two orders of magnitude compared to no action. Under Alternative 2b, risks to humans would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit use, risks to humans could be reduced to protective levels.

Alternative 2b includes no additional measures to reduce transport of COCs to groundwater. Therefore, concentrations of COCs in groundwater would continue to exceed protective levels for drinking water ingestion, and groundwater would continue to discharge COCs to surface water at concentrations that exceed surface water protection criteria. Use restrictions would be used to limit risks from ingestion of impacted groundwater. To the extent these institutional controls successfully limit use, risks could be reduced to protective levels.

Sediment. Under Alternative 2b, risks from exposure to sediment in the drainages and Blue Creek would likely decline somewhat over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas. Currently, the estimated non-cancer hazards and cancer risk from exposure to COCs in drainage sediments are 8 (adult) to 31 (child) and 9 in 10,000, respectively. The estimated non-cancer hazards from

exposure to COCs in Blue Creek sediments are 0.6 (adult) to 2 (child). No carcinogens were identified as COPCs for Blue Creek sediments. Information programs (e.g., signs and public notices) would be used to inform users of the potential risks resulting from exposure to drainage sediments and associated plants. To the extent these information programs successfully limit use, risks could be reduced to protective levels.

Residual human health risks from exposure to sediments in the open pits would be addressed by maintaining a water cover over the sediments and restricting access to the MA with a fence. The fence would also limit access of large animals. Alternative 2b contains no additional measures to reduce risks to ecological receptors from exposure to sediments in the drainages and Blue Creek. Risk reduction would occur over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas.

Surface Materials. Under Alternative 2b, a fence around the MA would be used to limit access and exposure to surface materials in the MA. To the extent the fence successfully limits access, risks could be reduced to protective levels. The perimeter fence would limit exposure of other large mammals to contaminated surface materials to protective levels. Risks to small terrestrial animals would continue largely unabated.

Gates and warning signage would be used to reduce residual human risks from exposure to surface materials in the haul roads and adjacent impacted areas. To the extent these measures successfully limits access, risks could be reduced to protective levels. These measures would not reduce risks to ecological receptors due to exposure to surface materials in the haul roads and adjacent areas.

Air. Risks to humans from exposure to airborne radon within both the MA and MAA exceed protective levels under current conditions. Under Alternative 2b, access to the MA, where the surface materials that are the primary radon sources are located, would be restricted by a fence. Because radon is a gas, it can migrate beyond the MA boundary. Based on the results of the HHRA, risks from inhalation of radon in the MAA would exceed protective levels under Alternative 2b.

Water Treatment Sludge. This alternative would produce an estimated average of 470 tons per year. Risks for potential exposure to water treatment sludge would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 2b.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage residual risks under Alternative 2b, including soil covers, water collection and storage, water treatment, sludge dewatering and solidification, and institutional controls, are evaluated in this section.

Soil Cover. Portions of the South Spoils were regraded, covered with 8 inches of topsoil, and vegetated by DMC between 1980 and 1982. The reclaimed areas have an overall slope of 2.2H:1V, except for the slopes above the PCP, which are steeper. Revegetation has been partially successful. The cover would be susceptible to erosion, particularly in areas of steeper slopes or poorer vegetation. Periodic inspections could effectively identify areas where the cover has been damaged, and additional cover material would be imported and placed to repair the damaged area. Additional revegetation may also be necessary periodically.

Water Collection and Storage. The existing water collection and storage system is generally effective for controlling discrete seeps at the toe of the South Spoils and runoff water at the site. A portion of the snowmelt and storm flow runoff bypasses the seep collection pumpback system, and alluvial groundwater also bypasses the system. There would not be an immediate concern about potential contaminated water releases in the event of short-term shutdowns of the treatment plant because Pit 3 provides a large temporary storage capacity. The water collection system would require long-term monitoring and periodic maintenance under Alternative 2b.

Water Treatment. The existing water treatment system has been in operation since 1992. It has been effective and reliable for removing COCs consistently to concentrations lower than NPDES permit levels during that period; however, it currently does not remove uranium, manganese, and sulfate to levels that meet tribal water quality standards. The barium chloride and lime precipitation processes used are conventional processes that are well understood. Long-term O&M would be required for water treatment, including periodic replacement of the WTP.

Sludge Dewatering and Solidification. Sludge dewatering using a filter press and solidification are conventional technologies with demonstrated reliability. Dewatering and solidification of sludge would reduce the mobility of COCs in treatment plant sludge to very low levels.

Sludge Disposal. An onsite sludge repository would include controls (double liner and composite final cap with lower permeability than liner) and performance monitoring to reliably reduce water percolation to levels similar to those required of hazardous waste landfills. Radium levels in sludge are similar to levels in waste rock; therefore, gamma radiation and radon emissions from solidified sludge would be similar to or less than from waste rock. For offsite sludge disposal, some potential exists for release of sludge as a result of an accident during transport; however, solidification of the sludge prior to transport would mitigate the impacts of any release. Disposal off site would require compliance with the Off Site Rule.

Institutional Controls. Institutional controls, such as access and use restrictions, can be protective, but are less reliable than containment or treatment response actions. Signs and fencing would require periodic maintenance. The long-term effectiveness of use restrictions would largely depend on their implementation and maintenance by the Tribal authorities or other entities. In particular, restrictions on surface water and plant use in the mine drainages and Blue Creek may be difficult to enforce. Information programs (e.g., signs, public notices, public meetings) rely on users voluntarily reducing exposures based on available information. The effectiveness of these programs may be limited by the ability to disseminate the information to all potential users. In addition, the effects of the information on potential users could diminish over time.

Summary. Under Alternative 2b, residual risks to tribal members and tribal resources would continue indefinitely. This includes risks posed by surface materials, surface water, sediments, groundwater, and air. Risks from all of these media would be managed through use of access and institutional controls, including a fence around the MA, where mine wastes would remain uncovered. Reliance on institutional controls and information programs lacks certainty at this site due to the regulatory context (e.g., limited Tribal mechanisms, allottee rights, and federal jurisdiction).

In addition, Alternative 2b necessitates long-term indefinite operation of the water treatment system, which will require perpetual funding for and performance of long-term operations and maintenance.

5.3.3.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2b includes treatment of contaminated seep, runoff, and pit water using an active ex-situ treatment process, which is described in Section 5.3.1.4. Under Alternative 2b, the toxicity of an estimated average of 80,000,000 gallons per year of contaminated water would be reduced using active treatment. The process would produce an estimated 470 tons of sludge per year. The sludge would be dewatered and solidified to reduce the potential for leaching of COCs. The active treatment process is considered irreversible; i.e., no significant remobilization of COCs would be expected assuming the sludge is disposed of such that it is not subject to leaching.

5.3.3.6 Short-Term Effectiveness

Protection of Community and Workers. Potential short-term impacts to the community and workers would result from contaminated dust generated during repository construction, if onsite sludge disposal is used. The impact of dust could be controlled using dust-suppression measures. Potential risks to workers would result from exposure to radiation during treatment of an estimated annual average of 80,000,000 gallons of water. These risks would be managed by using practices required by the plant's health and safety plan. If offsite sludge disposal is used, potential risks to the community would result from hauling an estimated annual average of 470

tons of sludge. These risks would be managed by employing standard hazardous materials hauling practices.

Environmental Impacts. Potential environmental impacts would result primarily from generation of sediment-laden runoff during repository construction, if onsite sludge disposal is used. The impact of this runoff could be limited using sediment control BMPs.

Time Until RAOs Are Achieved. RAOs for protection of humans and other large animals from direct exposure to MA surface materials, groundwater, surface water, and sediment would be achieved within less than one year, when the fence was complete. To the extent use restrictions are effective, RAOs for protection of human health from direct exposure to MAA surface water, groundwater, air, surface water, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to surface materials, sediments, and surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved within the foreseeable future.

Under Alternative 2b, the inability to achieve RAOs protective of ecological receptors in the foreseeable future will have a ongoing short-term impact on tribal resources and resource use.

5.3.3.7 Implementability

Technical Feasibility. Alternative 2b primarily includes technical components that are currently used at the site and therefore are proven to be implementable. The only new components would be sludge dewatering using a filter press, sludge solidification, and construction of a disposal area, if onsite sludge disposal is used. These components are technically implementable.

Monitoring could effectively measure the success of Alternative 2b in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 2b would preclude additional remedial action, if it were needed in the future.

Administrative Feasibility. A potential administrative feasibility consideration is the ability to meet the applicable or relevant and appropriate requirements of the Tribal HSCA for a new disposal facility for sludge, if onsite disposal is used. Compliance with the ESA may require consultation, a biological assessment, or other actions, which could delay initiation of cleanup. If offsite sludge disposal is used, a demonstration of no free liquids would be required to obtain a permit for disposal at the Richland facility.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require coordination and consultation with the Tribe, as well as extensive coordination with the BIA.

Availability of Services and Materials. If offsite sludge disposal is used, the LLRW disposal facility at Richland is estimated to have adequate capacity to accept waste until site closure in approximately 2056. However, as described in Section 5.3.1.4, DOH intends to limit disposal of uranium^{238} at the facility. At current sludge generation rates, the uranium^{238} limit would be reached in less than 10 years from the start of sludge disposal at the Richland facility. If the uranium^{238} limit cannot be exceeded, alternative disposal options would be needed at that time and may be more costly. The Envirocare low-level waste disposal facility in Clive, Utah is a potential alternate disposal site for the sludge. There are adequate sources of labor, equipment, and reagents to conduct active water treatment and dewater and solidify the sludge.

5.3.3.8 Cost

A range of costs has been estimated for Alternative 2b. The low end of the range ("base" cost) was estimated assuming onsite sludge disposal. The high end of the range ("base plus incremental" cost) was estimated assuming offsite sludge disposal at the Richland facility. The estimated costs are summarized as follows.

- Estimated capital cost = $4,800,000 (base) to $2,400,000 (base + incremental)
- Estimated average annual O&M cost = $1,300,000 (base) to $3,800,000 (base + incremental)
- Total estimated present worth cost (7%, 30 years) = $22,000,000 (base) to $44,000,000 (base + incremental)
- Total estimated present worth cost (3.1%, 140 years) = $49,000,000 (base) to $118,000,000 (base + incremental)

Alternative 2b also includes periodic costs for replacement of the WTP in year 10 and every 30 years thereafter. Table 5-12 presents a breakdown of estimated costs under Alternative 2b.

The primary cost uncertainties are related to the average annual volume of water that needs to be treated and the unit cost for offsite disposal of water treatment sludge. The average annual volume of water that needs to be treated is estimated based on historical annual treatment volumes at the site, corrected for changes in storage (Appendix C). While the historical data are believed to be the best available indicator of future treatment requirements, the actual volumes treated may vary from historical conditions.

The unit cost for offsite disposal will vary from year to year depending on the total amount of waste disposed of at the Richland facility by all generators, which could fluctuate. The method used to estimate the unit cost for sludge disposal is described in Appendix D. In addition, the unit cost for disposal could change if the uranium^{238} limit is reached and the Richland facility becomes unavailable for sludge disposal. The cost for offsite sludge disposal could be reduced if disposal options that are more cost-effective than the Richland facility are identified. Such

options may become available if the treatment system is modified to include pretreatment to remove uranium. If onsite disposal is selected, there may be user fees or additional costs that have not been identified at this time.

A preliminary evaluation of costs for modifications to the WTP that may be needed to meet surface water RAOs is presented in Section 5.5.

5.3.4 Alternative 3c (Aboveground Containment and Water Treatment)

5.3.4.1 Description

The primary elements of Alternative 3c include:

- Consolidation of the ore and protore stockpiles on top of the backfilled pits, with the area covered using a thick cover
- Regrading of other waste rock areas and placement of a thin cover
- Construction of a stormwater management system
- Pumping of groundwater from the backfilled pits, with active ex-situ treatment in the WTP
- Construction of fences around Pit 3 and Pit 4 to restrict access
- Use of Pit 3 to store contaminated water, with water pumped from Pit 3 and Pit 4 to the WTP for treatment, as needed, to maintain shallow water depths in the pits
- Expanded collection of MAA groundwater for active treatment in the WTP
- Paving of haul roads
- In-situ response actions for contaminated MAA sediments, including clean sediment covers and biostabilization
- Institutional controls, including use restrictions and information programs, and access controls
- Long-term monitoring and 5-year reviews

An overview summary of the elements of Alternative 3c is presented in Table 5-3. A summary of institutional controls included under Alternative 3c is presented in Table 5-4.

Alternative 3c includes consolidation and containment of ore and protore and in-place containment of waste rock. The open pits would remain open, with access restricted by a fence. The containment system includes a thick cover over areas containing ore and protore and a thin cover over other areas containing waste rock, as shown in Figure 5-3. Activities that could compromise the integrity of the containment systems, including residential use, excavation, and

motorized vehicle use, would be prohibited within the cover area. Because concentrations of COCs in groundwater beneath the MA would not be reduced to protective levels within the foreseeable future, installation of groundwater wells within the MA would be prohibited.

Under Alternative 3c, ore and protore would be consolidated in a centrally-located area on top of and adjacent to the existing backfilled pits. This area currently experiences a high rate of percolation, and groundwater quality in the backfilled pits is very poor. The consolidated ore and protore would be graded for drainage and covered with a thick cover, which would significantly reduce percolation and radon emanation. Thus, consolidation within a single area of the materials that have the highest radon flux and COC leaching rates would reduce the footprint of the thick cover and associated costs. In addition, reducing percolation into the backfilled pits, which is a large source of COCs removed in the WTP, would reduce water treatment and sludge disposal costs.

Other areas of the site containing waste rock would be regraded to a maximum side slope of 3H:1V and covered using a thin cover. In these areas, a thin cover would be adequate to comply with ARARs for radon flux. The thin cover would reduce external radiation to near background levels, and would significantly reduce percolation. Areas where the waste rock depth is shallow, including the Pit 4 Ready Line, Pit 2 Pile Reworked, and the remnant pile in the mine offices area, would be consolidated within adjacent areas to reduce the footprint of the cover. A layer of suitable soil would be placed over areas cleared of mine waste, as needed, to enhance revegetation of these areas.

The estimated areas of thick and thin covers are approximately 33 and 210 acres, respectively. A conceptual cover plan for Alternative 3c is shown in Figure 5-3. A conceptual grading plan for the South Spoils and backfilled pits areas under Alternative 3c is shown in Figure 5-4. Cross sections through the South Spoils and backfilled pits areas under Alternative 3c are shown in Figure 5-5. Estimated cut and fill volumes shown in Figure 5-5 indicate the conceptual grading plan is feasible, i.e., there is excess fill capacity of 1.9 million cy beneath the regraded surface. Final grading plans would be developed during remedial design.

Alternative 3c would reduce the volumes of surface water and oxygen that contact mining waste material, thereby reducing leaching of COCs and water treatment requirements. Based on hydrologic modeling presented in the Phase 1 Hydrologic Modeling Technical Memorandum (EPA 2002a), interflow[12] that results from percolation through 176 acres of currently uncovered, disturbed area accounts for an estimated annual average of 38 million gallons of water collected at the seeps. The total measured (1992 to 2000) annual average of water collected at the seeps is 44 million gallons. The source-containment measures implemented under Alternative 3c would reduce seep flows to an estimated annual average of 11 million gallons. Pit 3 would continue to

[12] At Midnite Mine, interflow consists of groundwater within the unconsolidated materials that generally flows on top of the pre-mining surface and converges toward the buried pre-mining drainages.

be used for temporary storage of contaminated seep water. Following implementation of source containment measures, including a stormwater collection system, runoff water would be uncontaminated and would be conveyed directly to the drainages south of the MA. This measure would reduce the volume of contaminated stormwater collected for treatment by an estimated annual average of 21 million gallons.

Treatment of water pumped from Pit 3 and Pit 4 to the WTP would be continued, as needed. For FS evaluation, it is assumed that treatment would be needed for the foreseeable future. The water levels in the pits would be maintained at current levels (less than elevation 2,580 feet above msl in Pit 3 and less than elevation 3020 feet above msl in Pit 4) so that the pits would act as groundwater sinks and discharge of water from the pits to groundwater would be limited.

Alternative 3c includes expanded groundwater collection and treatment. In addition to the existing seep collection points, the expanded water collection includes:

- Pumping water from the backfilled pits
- Groundwater collection trenches near the locations of the existing seep collection points
- Groundwater collection in areas further downgradient, where groundwater discharges to the Western, Central, and Eastern Drainages

Groundwater outflow from the backfilled pits is the source of more than half of the uranium loads discharged at the seeps. Data from the backfilled pits dewatering test indicates that COC concentrations in pumped water (which has a relatively short residence time in the pits) are about one-half the concentrations of water that collects in the pits under non-pumping conditions. Thus, direct pumping from the backfilled pits should result in reduced COC concentrations, treatment costs, and sludge production. The amount of groundwater flow, if any, into the backfilled pits after source containment measures have been implemented is not known at this time. For FS analysis, it was conservatively estimated that the long-term average groundwater flow into the pits would be the same as the flow that occurred during the backfilled pits dewatering test conducted between December 1999 and September 2000 (approximately 5 gpm).

Alluvial groundwater that bypasses the existing seep collection system at depth is the primary source of loads of COCs that discharge from groundwater to surface water in the drainages. Under Alternative 3c, this water would be collected in a collection trench and pumped to the WTP for treatment. The collection trench would be backfilled to limit surface water infiltration.

Current estimates of average groundwater discharge rates downgradient of the South Spoils seeps and assumed rates of groundwater extraction under Alternative 3c are summarized in Table 5-13. It is anticipated these discharges would be reduced to some extent by placement of cover systems in MA source areas. For FS analysis, it is assumed that 100% of the groundwater

discharge in the Central Drainage and 50% of the groundwater discharges in the Western and Eastern Drainages would be collected and treated under Alternative 3c.

Groundwater collection in the MAA drainages would be conducted using a combination of collection trenches and wells, as appropriate. Groundwater could also be treated in-situ using PRBs, if hydrogeologic conditions conducive to use of these systems exist, to avoid the cost of installing piping and pumping and treating water at the treatment plant. Use of PRBs could be evaluated during remedial design.

The reduction in volume of water collected from the South Spoils seeps would exceed the volume of water collected in the expanded water collection system; therefore, the WTP capacity would not need to be increased. The existing WTP would be modified, as necessary, to meet surface water RAOs.

For FS analysis, an estimate of future treatment requirements was made, as described in Appendix C. The estimated average future water treatment rate is approximately 38 million gallons per year, and the estimated average future sludge generation is 220 tons per year after dewatering (6,000 cubic feet per yea).

For this FS, costs have been developed for both onsite and offsite sludge disposal. Onsite and offsite sludge disposal are described in Section 5.3.1.4. Under both disposal options, it is assumed for FS analysis that the sludge would be further dewatered using a frame filter press and solidified. If onsite disposal is used, it is assumed for FS analysis that a facility would be constructed with a 100-year capacity. Based on an estimated average volumetric sludge generation rate of 6,000 cubic feet per year, the required disposal facility capacity would be 600,000 cubic feet (22,000 cy). For an assumed average waste thickness of 20 feet, the disposal facility footprint would be about 1 acre.

A combination of in-situ response actions, including containment using clean sediment covers and biostabilization using vegetation and other natural materials, would be used to remediate contaminated sediments in MAA drainages. These response actions would reduce exposure to contaminated sediments and reduce erosion and transport of contaminated sediments into Blue Creek. To limit the potential for recontamination, these actions typically would be implemented after source control within the MA was complete.

Exposure to contaminated haul road soil would be eliminated through placement of a pavement section consisting of 6 inches of clean structural fill and a surface layer of asphaltic concrete. An estimated 7,500 cy of clean fill would be required for construction of the pavement section. Institutional controls would be used that would require maintenance of the pavement section.

A potential staging of construction activities under Alternative 3c is as follows:

- The haul roads would be paved.
- Ore and protore would consolidated on top of the backfilled pits and covered. Groundwater collection trenches at the southern MA boundary would be constructed at the same time.
- Other waste rock areas would be regraded and covered.
- Cleanup actions for drainage sediments would be implemented.
- A period of monitoring would be conducted to evaluate the need for and locations of MAA groundwater collection wells.
- MAA groundwater collection wells would be installed, as needed.

It is estimated that implementation of Alternative 3c, not including the monitoring period and MAA well construction, would require approximately 3 to 4 years.

5.3.4.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. Ore, protore, and waste rock would be contained under a protective cover that would eliminate the direct ingestion pathway, reduce radon flux to the UMTRCA standard (20 pCi/m^2/s), and reduce external radiation to protective levels. The cover would also limit transport of contaminated surface materials in surface water, groundwater, and air. Land use limitations and periodic inspections and maintenance would be required to ensure the integrity of the cover. Land use limitations would affect the covered area shown in Figure 5-3.

Construction of the protective cover would involve regrading or consolidation of approximately 5,400,000 cy of ore, protore, and waste rock and importing 1,000,000 to 2,000,000 of cover materials. Regrading and consolidation operations may expose unoxidized materials to air, and potentially result in a short-term increase in COC concentrations in leachate. Regrading would also disturb areas of the South Spoils that have been reclaimed and the natural revegetation of the Hillside Dump. Mining and hauling of cover materials potentially would increase traffic hazards and short-term environmental impacts at borrow sites.

Surface Water and Sediment in Open Pits. Under Alternative 3c, Pit 3 would be used for temporary storage of contaminated seep water and groundwater. The pit lakes in Pit 3 and Pit 4 would be maintained at a shallow depth by pumping the contaminated pit water to the WTP for treatment. The quality of water in Pit 4 is expected to remain similar to current conditions for the foreseeable future. The quality of water in Pit 3 is expected to improve as a result of source containment measures. These measures would reduce seep flows, gradually resulting in a smaller portion of the pit water that consists of the more contaminated seep water. At best, the quality of water in Pit 3 could approach the quality of water in Pit 4 over time. However, the concentrations of COCs in water in both pits would exceed protective levels, and protection of humans and other larger mammals would be achieved through access restrictions using fences. Other animals would potentially be exposed to COCs in surface water and sediment in the open pits, to the extent they use the pits. Continued pumping and treatment of Pit 3 and Pit 4 water would be used to maintain these areas as groundwater sinks and limit the potential for additional impacts to groundwater.

Groundwater Within the MA. Under Alternative 3c, use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. The use restrictions would be needed for the foreseeable future. Collection and treatment of contaminated groundwater in the existing backfilled pits and in alluvial groundwater where it leaves the MA would further reduce the transport of contaminants from groundwater to surface water compared to existing conditions.

Surface Water and Groundwater in Mine Drainages and Blue Creek. Alternative 3c would improve groundwater and surface water quality in the mine drainages and Blue Creek compared to existing conditions by reducing contact of water and oxygen with ore, protore, and waste rock and through expanded collection and treatment of contaminated groundwater. The results of these actions are expected to include:

- Stream flows in the Western Drainage and Central Drainage would be enhanced because an estimated average of 21,000,000 gallons per year of runoff water within the MA would be isolated from ore, protore, and waste rock and conveyed to the drainages as clean water.
- Water treatment requirements and the potential for releases of contaminated water would be reduced because the estimated volume of contaminated seep water would decline from an average of approximately 44,000,000 gallons per year to an estimated average of 11,000,000 gallons per year.
- Surface water quality in the drainages would be improved because discharge of contaminated groundwater to the drainage streams would be reduced from an estimated average of 17,000,000 gallons per year (EPA 2002a) to an estimated average of 4,000,000 gallons per year.

As a result of these source control and expanded groundwater treatment actions, the estimated average uranium load in the Eastern Drainage under Alternative 3c would be reduced to approximately 21 pounds per year, compared to approximately 100 pounds per year under current conditions (Appendix F). This limited analysis suggests that the average uranium concentration in Blue Creek may be reduced to the background concentration over time. Surface water and groundwater quality in the mine drainages also may approach background conditions over time. A longer recovery period is anticipated for the drainages than for Blue Creek. The recovery period may be on the order of one to several decades. To the extent surface water and groundwater contain COCs at concentrations that exceed protective levels after implementation of Alternative 3c, use restrictions and information programs would be included to limit exposures.

Sediment in Mine Drainages and Blue Creek. Sediment quality in MAA drainages generally would continue to improve over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas. In addition, a combination of in-situ response actions, including containment using clean soil and biostabilization using vegetation and other natural materials, would further reduce exposures. These actions would limit exposure of humans and animals to concentrations of COCs and risk drivers that exceed background levels. Some short-term sediment quality impacts would likely occur as a result of remedy construction activities within the MA; however, these impacts could be limited through use of sediment control BMPs.

Haul Roads Soil. Under Alternative 3c, exposure to contaminated haul road soil would be eliminated through placement of a pavement section consisting of 6 inches of clean structural fill and a surface layer of asphaltic concrete. Institutional controls would be used that would require maintenance of the pavement section.

Plant and Animal Tissue. Under Alternative 3c, a soil cover would be used to reduce uptake of COCs by plants and animals within the MA. The soil cover should reduce concentrations of COCs in terrestrial plants in the MA to background levels, which would allow these plants to be safely consumed by livestock or other animals. In addition, the cover should reduce uptake of COCs in animal tissue through consumption of these plants to background levels, which would allow humans to safely consume the animal tissue.

Containment and treatment actions implemented under Alternative 3c would improve surface water and sediment quality within the MAA, which would reduce uptake of COCs by plants and animals. Information programs would be implemented to reduce human ingestion of contaminated plant and animal tissue from the MAA, including Blue Creek, until background concentrations of COCs in surface water and sediment are achieved.

Summary. In summary, Alternative 3c would provide protection of human health and the environment. Institutional controls would be used to reduce human exposure to surface water

and groundwater in the MA and MAA until background concentrations of COCs were achieved. Protection of the environment would be provided when background concentrations of risk drivers in MAA surface water were achieved. It is anticipated that a recovery period that may be on the order of one to several decades would be required to achieve background concentrations in MAA surface water and groundwater. Restrictions on surface water and groundwater use within the MA would be needed for the foreseeable future.

5.3.4.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations.

Under Alternative 3c, loads of COCs and risk drivers discharged to Blue Creek and the mine drainages would be further reduced through source containment and expanded groundwater collection and treatment. As a result, concentrations of these contaminants may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. The time frame for Blue Creek would be shorter than for the mine drainages.

The concentrations of some constituents in the WTP effluent, including uranium, manganese, and sulfate, currently exceed Tribal water quality standards and background. Treatability studies would be needed to determine what modifications would need to be made to the WTP to further reduce concentrations of these constituents to meet water quality ARARs. As discussed in Section 5.3.1.4, EPA is continuing to work with the Tribe to determine discharge requirements

for sulfate. A preliminary evaluation of potential costs to treat sulfate to a concentration of 250 mg/L or lower is presented in Section 5.5.

Groundwater. Under Alternative 3c, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 243 acres). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations.

Alternative 3c includes source containment and expanded groundwater collection and treatment, which should prevent further migration of the plume and improve groundwater quality compared to current conditions. Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades.

Within the WMA, Alternative 3c includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 3c, areas with concentrations of COCs that exceed ARARs would be covered, which would result in compliance with potential ARARs for surface materials. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 3c, areas with concentrations of COCs that exceed ARARs would be addressed using in-situ containment methods, which would result in compliance with potential ARARs for sediment.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Protective covers installed within the MA under Alternative 3c would reduce radon flux to levels that comply with the 40 CFR 61 standard.

Waste Management. If onsite disposal of treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. Alternative 3c would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

5.3.4.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 3c to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and water treatment sludge at the conclusion of remedial activities under Alternative 3c are evaluated in this section.

Surface Water and Groundwater. Following implementation of Alternative 3c, risks from exposure to surface water and groundwater would be further reduced compared to existing conditions. The largest risk reduction compared to current conditions would occur in surface water and groundwater in the drainages as a result of expanded groundwater collection and treatment. Under Alternative 3c, uranium loads in the Eastern Drainage would be an estimated 21 pounds per year, compared to an estimated 100 pounds per year under current conditions. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, would be reduced under Alternative 3c. Risks would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit use, risks could be reduced to protective levels.

In the open pits, water quality would be improved and risks would be reduced as a result of source containment and reduced storage of seep water in Pit 3. However, concentrations of COCs in pit water would likely remain significantly elevated relative to background, and access

restrictions would be used to limit exposure. To the extent fences effectively limit exposure, risks could be reduced to protective levels. Fences would not be effective for reducing exposure of birds and other small animals.

Sediment. Under Alternative 3c, risks from exposure to COCs in sediment in the drainages and Blue Creek would decline from current levels as a result of isolation of ore, protore, and waste rock in the MA from surface water runoff and sediment response actions, including containment using clean sediment and biostabilization using vegetation and other natural materials. Sediments in the open pits would continue to contain elevated levels of COCs as a result of continued settling of suspended particles in collected seep water and erosion of the open pit highwalls. Risks from exposure to sediments in the open pits would be addressed by maintaining a water cover over the sediments and restricting access to the pits with fences. The fences would not be effective for reducing exposure of birds and other small animals.

Surface Materials. Risks from exposure to external radiation and COCs in surface materials would be reduced to acceptable levels, as long as the integrity of the cover system is maintained.

Air. The areawide average radon flux in the MA would be reduced from approximately 50 $pCi/m^2/s$ to 20 $pCi/m^2/s$ or less. The flux level of to 20 $pCi/m^2/s$ was adopted in NESHAPs and UMTRCA for radon source areas (e.g., the MA) to provide acceptable risk levels for residential use in adjacent areas (e.g., the MAA). Land use restrictions that limit used of the covered areas to transient foot traffic would be used to reduce risks from radon inhalation within the MA following attainment of the 20 $pCi/m^2/s$ standard.

Water Treatment Sludge. Risks from potential exposure to water treatment sludge (estimated average of 220 tons per year) would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 3c.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage residual risks under Alternative 3c, including protective covers, water collection wells and trenches, stormwater management system, biostabilization, institutional controls, and other controls are evaluated in this section.

Protective Covers. Covers may be susceptible to erosion, particularly on steep slopes or in areas where revegetation is unsuccessful. Covers would be placed on slopes no steeper than 3H:1V and provided with stormwater drainage ditches to limit the potential for erosion. Covers can also be damaged by human activities, and institutional controls would be used to limit activities such

as off-road vehicle travel and excavation. Periodic inspections could effectively identify areas where the cover has been damaged by events such as erosion or blowdown,[13] and additional cover material would be imported and placed to repair the damaged area. Additional revegetation also may be necessary periodically. The effectiveness of covers can be reduced over time by environmental factors, including cracking from freeze-thaw action or desiccation and holes produced by burrowing animals and plant roots. The thickness of the cover includes a factor of safety to account for potentially reduced effectiveness due to these environmental factors.

Water Collection Wells and Trenches. Water collection wells and trenches are susceptible to plugging due to metals precipitation. Periodic maintenance, and potentially replacement, may be necessary to maintain their function.

Stormwater Management System. Stormwater conveyance channels are susceptible to erosion and overtopping during large storm events. The channels can be designed to minimize these effects; however, periodic inspections and maintenance may be required.

Biostabilization. Biostabilization measures may be damaged by environmental stresses such as flooding and droughts, and periodic replacement of some components may be required. Phytoxicity may hinder re-establishment of vegetation in some areas. As stream channel stability improves over time (as a result of successional recovery of physical habitat structure), maintenance requirements are expected to decrease. Periodic inspections and adaptive management could be used to identify problem areas and appropriate corrective actions.

Institutional Controls. Considerations for institutional controls would be similar to those described under Alternative 2b. Because Alternative 3c involves containment of ore, protore, and waste rock in place, long-term land use restrictions would be required to protect the integrity of the containment system. The long-term effectiveness of land use restrictions would depend on continued enforcement by the Tribal authorities or other entities.

Other Controls. The adequacy and reliability of water collection, water treatment, sludge dewatering and solidification, and sludge disposal under Alternative 3c would be the same as described under Alternative 2b.

Summary. Under Alternative 3c, residual risks to tribal members and tribal resources would be reduced from current conditions. However, residual risks would continue to exist in surface materials, surface water, sediments, and groundwater. Human health risks from these media would be managed through use of access and institutional controls. These controls include restrictions on the open pits (67 acres), WTP (3 acres), cover areas (243 acres), and sludge disposal site, if any (2 acres). Reliance on institutional controls and information programs lacks

[13] The Ponderosa pine is the most common tree in the Midnite Mine area. The Ponderosa pine has a taproot that limits its susceptibility to being blown down.

certainty at this site due to the regulatory context (e.g., limited Tribal mechanisms, allottee rights, and federal jurisdiction).

In addition, Alternative 3c necessitates long-term indefinite operation of the water treatment system, which will require perpetual funding for and performance of long-term operations and maintenance. Under Alternative 3c, the estimated average future water treatment rate is approximately 38 million gallons per year

5.3.4.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 3c includes treatment of contaminated seep water, MAA groundwater, and pit water using an active ex-situ treatment process, which is described in Section 5.3.1.4. Under Alternative 3c, the toxicity of an estimated average of 38,000,000 gallons per year of contaminated water would be reduced using active treatment. The water treatment sludge would be dewatered and solidified to reduce the potential for leaching of COCs. The process would produce an estimated 220 tons of dewatered and solidified sludge per year. The active treatment process is considered irreversible; i.e., no significant remobilization of COCs would be expected assuming the sludge is disposed of such that it is not subject to leaching.

5.3.4.6 Short-Term Effectiveness

Protection of Community and Workers. The primary considerations for protection of the community and workers during remedy implementation include traffic hazards and noise associated with transporting an estimated 1,000,000 to 2,000,000 cy (approximately 50,000 to 100,000 truck trips) of cover material from offsite borrow sources and contaminated dust generated during earthwork operations. Community impacts from cover material hauling could be mitigated to some extent by using limited hours for hauling and employing traffic control at key points, as necessary. The impact of dust could be controlled using dust-suppression measures. Potential risks to workers would result from exposure to radiation during treatment of an estimated annual average of 38,000,000 gallons of water. These risks would be managed by using practices required by the plant's health and safety plan. If offsite sludge disposal is used, potential risks to the community would result from hauling an estimated annual average of 220 tons of sludge. These risks would be managed by employing standard hazardous materials hauling practices.

Environmental Impacts. Potential environmental impacts include the generation of sediment-laden runoff during earthwork operations. The impact of this runoff could be limited using sediment control BMPs. Earthwork operations may expose unoxided ore, protore, and waste rock to air, and potentially result in a short-term increase in COC concentrations in leachate.

Collection of alluvial groundwater could reduce groundwater levels and base flows in the MAA drainages, which could have adverse effects on aquatic and riparian habitat. These effects may

be mitigated by natural infiltration of clean runoff from covered areas of the MA that would be conveyed to the MAA drainages. If needed, potential effects could be further mitigated by reintroducing treated water into the alluvial aquifer through infiltration trenches or injection wells.

Potential short-term impacts would result from sediment stabilization or removal in riparian areas within the drainages. Engineering controls such as sediment fencing, sediment traps, revegetation, and biostabilization measures would be used to limit these impacts.

If new offsite borrow sources are developed for cover material, the potential for short-term environmental impacts at these sites would exist. These impacts could include increased uncontaminated sediment loads from runoff and erosion, destruction of existing vegetation and habitat, and degradation of topsoil quality. Standard engineering controls such as sediment fencing and revegetation would reduce these impacts.

Time Until RAOs are Achieved. RAOs for surface materials and air would be achieved when cover construction is complete. An estimated 2 to 3 years would be required for development of cover materials sources and cover construction. MAA sediment response actions could be completed and sediment RAOs achieved within one year of completion of cover construction. To the extent use restrictions are effective, RAOs for protection of human health from exposure to MA and MAA surface water, groundwater, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to MAA surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved at the completion of remedy construction. A period of natural recovery that may be on the order of one to several decades may be needed to achieve these RAOs.

Under Alternative 3c, the time frame of one to several decades to achieve RAOs for ecological receptors indicates an ongoing short-term impact on tribal resources.

5.3.4.7 Implementability

Technical Feasibility. Alternative 3c is considered to be technically feasible. The remedy could be implemented using conventional construction equipment and techniques.

Monitoring could effectively measure the success of Alternative 3c in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 3c would preclude additional remedial action, if it were needed in the future. Once a cover is in place, however, additional remediation that involves moving covered materials would be more costly.

Administrative Feasibility. A potential administrative feasibility consideration is the ability to meet the applicable or relevant and appropriate requirements of the Tribal HSCA for a new disposal facility for sludge, if onsite disposal is used.

Compliance with the ESA may require consultation, a biological assessment, or other actions which could delay initiation of cleanup. Offsite actions may require permits. Surface mining permits from Tribal, state, or local agencies may be required to excavate borrow materials. Potential difficulties in obtaining permits may delay implementation or increase costs. If offsite sludge disposal is used, a demonstration of no free liquids would be required to obtain a permit for disposal at the Richland facility.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require coordination with the BIA and coordination and consultation with the Tribe.

Availability of Services and Materials. A primary implementability consideration is the availability of suitable material for cover construction. The volume of material required would depend on the material characteristics and cover design. Table 5-5 provides estimated volumes of required for various material characteristics and cover designs. For FS analysis it is assumed an evapotranspiration cover would be used, and an estimated 1,000,000 to 2,000,000 cy of cover material would be required. Identification and development of materials sources could impact construction scheduling.

Considerations related to the availability of offsite disposal capacity for an estimated average of 6,000 cubic feet of water treatment sludge per year are described under Alternative 2b. There are adequate sources of labor, equipment, and reagents to conduct active water treatment and dewater and solidify the sludge.

5.3.4.8 Cost

A range of costs has been estimated for Alternative 3c. The low end of the range ("base" cost) was estimated assuming onsite sludge disposal. The high end of the range ("base plus incremental" cost) was estimated assuming offsite sludge disposal at the Richland facility and increased thicknesses of protective covers.[14] The estimated costs are summarized as follows.

- Estimated capital cost = $65,000,000 (base) to $71,000,000 (base + incremental)
- Estimated average annual O&M cost = $1,300,000 (base) to $2,600,000 (base + incremental)

[14] Low end of range cover construction costs were estimated assuming a thin cover thickness of 2 feet, a thick cover thickness of 6 feet, and a one-way materials haul distance of 28 miles. High end of range cover construction costs were estimated assuming a thin cover thickness of 4 feet, a thick cover thickness of 10 feet, and a one-way materials haul distance of 7.5 miles.

- Total estimated present worth cost (7%, 30 years) = $82,000,000 (base) to $101,000,000 (base + incremental)
- Total estimated present worth cost (3.1%, 140 years) = $108,000,000 (base) to $152,000,000 (base + incremental)

Alternative 3c also includes periodic costs for replacement of the WTP in year 10 and every 30 years thereafter. Table 5-14 presents a breakdown of estimated costs under Alternative 3c.

The primary capital cost uncertainty is related to the cost of constructing protective covers, including providing suitable material for construction. The estimated cost of cover construction is about 60 percent of the estimated total capital cost. To the extent suitable cover material can be developed within or adjacent to the site, the cost of cover construction could be reduced.

The primary O&M cost uncertainty is related to offsite disposal of water treatment sludge. The future cost of sludge disposal depends on the volume of sludge produced and the unit cost for disposal. The volume of sludge produced will depend on the volume of water treated and the characteristics of the water (i.e., the amount of sludge produced per 1,000 gallons of water treated). As discussed in Section 5.3.1.4, the unit cost for disposal will vary from year to year depending on the total amount of waste disposed of at the Richland facility by all generators. The cost for offsite sludge disposal could be reduced if disposal options that are more cost-effective than the Richland facility are identified. Such options may become available if the treatment system is modified to include pretreatment to remove uranium. If onsite disposal is selected, there may be user fees or additional costs that have not been identified at this time.

As preliminary evaluation of costs for any modifications to the WTP that may be needed to meet surface water RAOs is presented in Section 5.5.

5.3.5 Alternative 3d (Aboveground Containment and In-Situ Water Treatment)

5.3.5.1 Description

Alternative 3d includes institutional controls and containment of ore, protore, and waste rock as described under Alternative 3c. The primary elements of Alternative 3c incorporated in Alternative 3d include:

- Consolidation of the ore and protore stockpiles on top of the backfilled pits, with the area covered using a thick cover
- Regrading of other waste rock areas and placement of a thin cover
- Construction of a stormwater management system
- Paving of haul roads

- In-situ response actions for MAA sediments, including clean sediment covers and biostabilization
- Institutional controls, including use restrictions and information programs, and access controls
- Long-term monitoring and 5-year reviews

Alternative 3d differs from Alternative 3c in three elements:

- Collection of MAA groundwater for active treatment in the WTP is not included. Instead, groundwater and seeps in the MAA drainages would be treated in-situ treatment using subsurface PRBs.
- Water in the open pits would be treated in-situ, with active treatment in the WTP of water removed to maintain a constant pit water level.
- Groundwater would not be pumped directly from the backfilled pits; rather, outflow from the backfilled pits would be treated in-situ where it emerges at the Central Drainage seeps and as alluvial groundwater in the MAA.

An overview summary of the elements of Alternative 3d is presented in Table 5-3. A summary of institutional controls included under Alternative 3d is presented in Table 5-4.
The conceptual cover plan for Alternative 3d is equivalent to that for Alternative 3c. The conceptual plan view for both is shown in Figure 5-3. A conceptual grading plan for the South Spoils and backfilled pits areas for both alternatives is shown in Figure 5-4. Cross sections through the South Spoils and backfilled pits areas under both alternatives are shown in Figure 5-5.

Groundwater and seeps in the MAA drainages would be treated in-situ treatment using subsurface PRBs. The PRBs would be located near the existing pumpback systems and would extend through the alluvial aquifer to bedrock. The PRBs would take advantage of the site topography, which would funnel interflow water and shallow alluvial groundwater to the PRBs. The assumed locations of the PRBs are shown in Figure 5-6. Seepage rates would be reduced after construction of the containment system, which would increase the likelihood that PRBs could be implemented successfully. Under Alternative 3d, surface water flows would increase in the Central and Western Drainages and decline in the Eastern Drainage compared to current conditions, which are affected by seep collection and the WTP discharge.

Treatability studies would be required to design the PRBs. Reactive materials in the PRBs might include zero-valent iron (ZVI), apatite, limestone, natural zeolites, organic material (to create conditions suitable for growth of sulfate-reducing bacteria), or other materials. For FS analysis, it is assumed the PRBs would be similar to the PRB installed at the Monticello, Utah site, where the primary groundwater COCs are uranium and manganese (DOE 2000). The PRBs would be

constructed so that groundwater flowed through a zone containing ZVI, followed by flow through an oxygenated zone. In the ZVI zone, Fe(0) would be oxidized to Fe(II), and constituents in groundwater would be reduced to less soluble forms. For example, uranium would be reduced from U(VI) to U(IV), which is insoluble. In the oxygenated zone, iron and manganese would be precipitated as oxides.

For FS analysis, it is estimated that a total of 25,000 tons of ZVI would be needed to treat the seep water for 15 years (Appendix C). This volume was extrapolated from the design of the Monticello PRB. Because some clogging tends to occur near the upgradient face of the reactive media, the thickness of the reactive media would be limited to 7.5 feet. Thus, in the Central and Western Drainages, where relatively large amounts of ZVI are required, more than one PRB may be needed at the South Spoils seep locations to provide for 15 years of treatment. The conceptual design of the PRBs used for FS analysis is shown in Figure 5-7.

Although the PRBs would operate as passive treatment systems, O&M would be required. The O&M would include periodic replacement or regeneration of spent reactive media. The spent media may contain concentrations of radionuclides that are high enough that the media would have to be disposed of as radioactive waste. For FS analysis, it is assumed the spent reactive media would be replaced and disposed of as radioactive waste.

Under Alternative 3d, the open pits would remain open and the pit water would be treated in-situ. The existing WTP would be used to treat water removed to control pit water level, unless the water in the pits achieved RAOs. Pumpback from the seep collection system to Pit 3 would be discontinued. In-situ treatment would consist of adding lime, organic material, and nutrients to the pit water. The lime would neutralize acidity generated by sulfide minerals. The organic material would be used as a carbon source by naturally-occurring microorganisms, resulting in anoxic conditions, growth of sulfate-reducing bacteria, and precipitation of dissolved metals and radionuclides as insoluble minerals. These metals and radionuclides would be precipitated as sediment on the bottom of the pits. The sediment would be kept submerged to limit exposure.

Treatability studies would be needed to select the types and quantities of lime, organics, nutrients, and other amendments that may be useful for precipitating dissolved metals in-situ. The amendments would be applied at the pit water surface, and it is assumed the amendments and pit water would mix at depth as a result of thermal turnover of the pit lake. The degree of mixing that would occur, as well as the frequency that reapplication of amendments would be required, is uncertain at this time. For FS analysis, a reapplication interval of 5 years has been assumed.

In-situ pit water treatment using addition of organic material to stimulate sulfate-reducing bacteria has been conducted at a pit lake in Sweetwater, Wyoming. The treatment was only moderately effective at reducing uranium concentrations. Concentrations were reduced from approximately 8 mg/L prior to treatment to approximately 4 mg/L six months after treatment

(Wyoming Mining Association 2003). Thus, it is assumed for FS analysis that the pit water would not be discharged directly to surface water or groundwater. Pumping of pit water would be continued, as needed, to control pit water level. The water would be further treated in the existing WTP, which would be modified, as necessary, to meet surface water RAOs. Actions included to address contaminated haul road soils and contaminated drainage sediments are the same as described under Alternative 3c.

A potential staging of construction activities under Alternative 3d is as follows:

- The haul roads would be paved.
- Ore and protore would consolidated on top of the backfilled pits and covered. PRBs at the southern MA boundary would be constructed and initial pit water treatment would be conducted at the same time.
- Other waste rock areas would be regraded and covered.
- Cleanup actions for drainage sediments would be implemented.
- A period of monitoring would be conducted to evaluate the need for and locations of additional PRBs for treating MAA groundwater.
- Additional PRBs for treating MAA groundwater collection wells would be constructed, as needed.

An estimated 2 to 3 years would be required for development of cover materials sources and cover construction. Treatability studies, construction of PRBs, and initial pit water treatment would be conducted concurrently with cover construction. The construction time for PRBs could be affected by the availability of reactive media. It is estimated that implementation of Alternative 3d, not including the monitoring period and construction of additional PRBs in the MAA, would require approximately 3 to 5 years.

5.3.5.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. The evaluation of protection of human health and the environment for MA surface materials, including external radiation and airborne radon is the same as under Alternative 3c.

Surface Water and Sediment in Open Pits. Under Alternative 3d, the quality of water in Pit 3 is expected to improve because storage of contaminated seep water in the pit would be discontinued. In-situ water treatment would further improve the quality of water in Pits 3 and 4. However, based on limited data in the technical literature for in-pit water treatment, it is not expected that concentrations of COCs would meet surface water or sediment RAOs. Consequently, further protection of humans and other large mammals would be achieved by restricting access to the open pits using fences. Other animals would potentially be exposed to COCs in pit water and sediment at concentrations that exceed protective levels.

Groundwater Within the MA. Under Alternative 3d, use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. The use restrictions would be needed for the foreseeable future. Contaminated groundwater, including outflow from the existing backfilled pits, would be treated using PRBs where it leaves the MA in seeps and alluvial groundwater. Treatment of alluvial groundwater would further reduce the transport of contaminants from MA groundwater to surface water compared to existing conditions.

Groundwater and Surface Water in Mine Drainages and Blue Creek. Alternative 3d would improve groundwater and surface water quality compared to existing conditions by reducing contact of water and oxygen with ore, protore, and waste rock and through in-situ treatment of contaminated seep water and groundwater using PRBs. The results of these actions are expected to include:

- Stream flows in the Western Drainage and Central Drainage would be enhanced because an estimated average of 21,000,000 gallons per year of runoff water within the MA would be isolated from ore, protore, and waste rock and conveyed to the drainages as clean water.
- Water treatment requirements and the potential for releases of contaminated water would be reduced because the estimated volume of contaminated seep water would be reduced from an average of approximately 44,000,000 gallons per year to an estimated average of 14,000,000 gallons per year.
- An estimated 14,000,000 gallons of seep water and 6,000,000 gallons of alluvial groundwater would be treated using PRBs.
- Surface water quality in the drainages would be improved because discharge of contaminated groundwater to the drainage streams would be reduced from an estimated average of 17,000,000 gallons per year to an estimated average of 6,000,000 gallons per year.

As a result of these source control and water treatment actions, the estimated average uranium load in the Eastern Drainage under Alternative 3d would be reduced to approximately 28 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than

two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1 (Appendix F).

This limited analysis suggests that the average uranium concentration in Blue Creek may be reduced to the background concentration over time. Based on initial treatability test results shown in Table 5-15, the effectiveness of ZVI for removing manganese is variable. As a result, it is not known whether Alternative 3d would achieve surface water RAOs for manganese in Blue Creek.

Surface water and groundwater quality in the mine drainages may also approach background conditions over time. It is anticipated a longer recovery period would be needed than for Blue Creek. The recovery period may be on the order of one to several decades. To the extent surface water and groundwater contain COCs at concentrations that exceed protective levels after implementation of Alternative 3d, use restrictions and information programs would be included to limit human exposures.

Sediment in Mine Drainages and Blue Creek. The evaluation of protection of human health and the environment for sediment in the mine drainages and Blue Creek is the same as under Alternative 3c.

Haul Roads Soil. The evaluation of protection of human health and the environment for haul roads soil is the same as under Alternative 3c.

Plant and Animal Tissue. The evaluation of protection of human health and the environment for plant and animal tissue is the same as under Alternative 3c.

Summary. In summary, Alternative 3d would provide protection of human health and the environment. Institutional controls would be used to reduce human exposure to surface water and groundwater in the MA and MAA until background concentrations of COCs were achieved. Protection of the environment would be provided when background concentrations of risk drivers in MAA surface water were achieved. It is anticipated that a recovery period that may be on the order of one to several decades would be required to achieve background concentrations in MAA surface water and groundwater. Restrictions on surface water and groundwater use within the MA would be needed for the foreseeable future.

5.3.5.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with

the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations.

Under Alternative 3d, loads of COCs and risk drivers discharged to Blue Creek and the mine drainages would be further reduced through source containment and expanded groundwater treatment. As a result, concentrations of these contaminants may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. The time frame for Blue Creek would be shorter than for the mine drainages.

The concentrations of some constituents in the WTP effluent, including uranium, manganese, and sulfate, currently exceed Tribal water quality standards and background. Under Alternative 3d, pit water would be treated in-situ; however, it is likely additional treatment in the WTP would be needed to meet surface water discharge ARARs. Should additional treatment be needed, treatability studies would be needed to determine what modifications would need to be made to the WTP to further reduce concentrations of these constituents to meet water quality ARARs. As discussed in Section 5.3.1.4, EPA is continuing to work with the Tribe to determine discharge requirements for sulfate. A preliminary evaluation of potential costs to treat sulfate to a concentration of 250 mg/L or lower is presented in Section 5.5.

Groundwater. Under Alternative 3d, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 243 acres). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations.

Alternative 3d includes source containment and expanded groundwater collection and treatment, which should prevent further migration of the plume and improve groundwater quality compared to current conditions. Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades.

Within the WMA, Alternative 3d includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 3d, areas with concentrations of COCs that exceed ARARs would be covered, which would result in compliance with potential ARARs for surface materials. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 3d, areas with concentrations of COCs that exceed ARARs would be addressed using in-situ containment methods, which would result in compliance with potential ARARs for sediment.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Protective covers installed within the MA under Alternative 3d would reduce radon flux to levels that comply with the 40 CFR 61 standard.

Waste Management. If onsite disposal of spent reactive media and treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive

requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. Alternative 3d would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

5.3.5.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 3d to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and water treatment residuals at the conclusion of remedial activities under Alternative 3d are evaluated in this section.

Surface Water and Groundwater. Following implementation of Alternative 3d, risks from exposure to surface water and groundwater would be further reduced compared to existing conditions. Under Alternative 3d, uranium loads in the Eastern Drainage would be an estimated 28 pounds per year, compared to an estimated 100 pounds per year under current conditions. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, would be reduced under Alternative 3d. Risks would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit use, risks could be reduced to protective levels.

Pit water quality is expected to improve as a result of discontinuing seep pumpback and conducting in-situ treatment. Based on data from the Sweetwater pit, uranium may be reduced by approximately 50%. However, concentrations of COCs in pit water would likely remain elevated relative to background, and access restrictions would be used to limit exposure. To the extent the fence effectively limits exposures for humans and large mammals, risks could be reduced to protective levels.

Sediment. Under Alternative 3d, risks from exposure to COCs in sediment in the drainages and Blue Creek would decline from current levels as a result of isolation of ore, protore, and waste rock in the MA from surface water runoff and sediment response actions, including containment using clean sediment and biostabilization using vegetation and other natural materials. Risks in Blue Creek may be reduced to protective levels over time. Sediments in the open pits would continue to contain elevated levels of COCs as a result of precipitation of dissolved COCs and continued erosion of the open pit highwalls. Risks from exposure to sediments in the open pits

would be addressed by maintaining a water cover over the sediments and restricting access to the MA with a fence.

Surface Materials. The evaluation of residual risks due to surface materials is the same as under Alternative 3c.

Air. The evaluation of residual risks due to radon in air is the same as under Alternative 3c.

Treatment Residuals. An estimated 25,000 tons of reactive media would be used, which would accumulate COCs over time. The reactive media would be below the ground surface, and risk of exposure to these materials would be limited. However, the reactive media would periodically be replaced (assumed for the FS every 15 years), and the excavated material would be disposed of in an onsite or offsite disposal facility. This process could lead to worker exposures.

If additional ex-situ treatment of pit water is needed, risks from potential exposure to water treatment sludge (estimated average of 50 tons per year) would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 3d.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage risks under Alternative 3d, including permeable reactive barriers, in-situ pit water treatment, and other controls, are evaluated in this section.

Permeable Reactive Barriers. There are only limited field data with which to evaluate the long-term adequacy and reliability of PRBs. The maximum field history for a full-scale PRB is approximately 7 years (ESTCP 2003). Consequently, it is not possible to extrapolate the performance of PRBs over the full 30-year FS performance period with certainty.

There are several factors that could affect the performance of PRBs. These factors include potential flow short-circuiting (i.e., formation of preferential flow pathways that utilize only a limited area of the barrier), large variations in the magnitude of flow, coating and deactivation of reactive media surfaces, reduced hydraulic performance due to clogging of the media by precipitates or biofilms, and variable effectiveness for different COCs. The seep water at Midnite Mine is saturated with oxygen, which could lead to problems with precipitation of metal oxides that could coat and clog the reactive media.

At Monticello, uranium concentrations in groundwater of 400 ug/L were reduced to 2 to 14 ug/L using ZVI. By comparison, concentrations of uranium in seep water and groundwater at Midnite Mine typically range from 2,000 to 70,000 ug/L. The concentrations of manganese and iron in

the groundwater increased in the ZVI zone but were buffered within several feet of exiting it (EPA 2003c). Abiotic sulfate removal by ZVI is limited; however, anoxic conditions would exist within the reactive media, and removal of sulfate by sulfate-reducing bacteria may occur in the field.

Laboratory batch tests have been conducted using site water and 3 reactive media (ZVI from two sources and a combination of ZVI and zeolite). The site water was alluvial groundwater from the Western Drainage (well GW-35A) and the lower Eastern Drainage (well MWED-10). Results of the batch tests are presented in Table 5-15 (Hale 2004). The results indicate ZVI is effective for many metals and radionuclides, including uranium; however, high rates of manganese removal were only achieved when the pH was raised above 9.

Periodic replacement and disposal or regeneration of spent media would be required. Collection and analysis of treated water samples would be used to evaluate the effectiveness of the PRBs over time.

In-Situ Pit Water Treatment. There is limited existing information available to evaluate the adequacy and reliability of in-situ pit water treatment. In-situ pit water treatment has been conducted at Sweetwater, Wyoming. In-situ treatment at the Sweetwater site was only moderately effective at reducing uranium concentrations. Concentrations were reduced from approximately 8 mg/L prior to treatment to approximately 4 mg/L six months after treatment. Reapplication of the amendments would be required periodically as acidity, metals, and radionuclides are added to the pit water from runoff from the highwalls and groundwater.

Contaminated sediments would be precipitated on the floor of the pit, which would be a potential ecological exposure pathway. If the pit sediments became oxidized, uranium as insoluble U(IV) would be oxidized to soluble U(VI) and could be released into the water column. There is some potential this could occur over time if reapplications of amendments that stimulate the growth of oxygen-consuming microorganisms were discontinued. Long-term water quality monitoring would be needed to evaluate the effectiveness of the treatment and identify the need for reapplication of amendments.

Other Controls. The adequacy and reliability of controls including protective covers, stormwater management systems, biostabilization, and institutional controls would be the same as described under Alternative 3c. The adequacy and reliability of ex-situ water treatment, sludge dewatering and solidification, and sludge disposal under Alternative 3d would be the same as described under Alternative 2b.

Summary. Under Alternative 3d residual risks to tribal members and tribal resources would be reduced from current conditions. However, residual risks would continue to exist in surface materials, surface water, sediments, and groundwater. Risks from these media would be managed through use of access and institutional controls. These controls include restrictions on

the open pits (67 acres), WTP (3 acres), cover areas (243 acres), and sludge disposal site, if any (2 acres). Reliance on institutional controls and information programs lacks certainty at this site due to the regulatory context (e.g., limited Tribal mechanisms, allottee rights, and federal jurisdiction).

Alternative 3d would require some reapplication of material to in-situ pit and some ex-situ water treatment. To the extent that such water treatment is needed, this would require long-term funding, operation, and maintenance.

5.3.5.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under Alternative 3d, the toxicity of seep water and MAA groundwater would be reduced using PRBs, and the toxicity of pit water would be reduced through in-situ addition of lime and organic amendments. Using PRBs, the toxicity of an estimated average of 22,000,000 gallons per year of contaminated seep water would be reduced. The achievable treated water concentrations will vary depending on the contaminant. For uranium, removal rates of 99 percent have been achieved at the Monticello, Utah site. Batch tests using site groundwater also indicated removal rates for uranium of 98 to 99 percent. The precipitation reactions that occur using ZVI can be considered irreversible, i.e., no significant remobilization of metals removed by the PRBs back into the environment would be expected.

Treatment residuals produced would consist of spent reactive media. An estimated 25,000 tons of spent media would be produced every 15 years. At this time, there is no process available to regenerate the spent media, and it would require disposal. Treatability testing would be required to select the reactive media and evaluate removal efficiencies for various contaminants, volumes of media required, and residual characteristics (e.g., whether the spent media would display a hazardous waste characteristic and require disposal as a mixed radioactive waste).

The toxicity of an estimated average of 16,000,000 gallons per year of contaminated water in Pit 3 and Pit 4 would be reduced using in-situ treatment. The achievable treated pit water concentrations will vary depending on the contaminant. At the Sweetwater Pit site in Wyoming, the removal efficiency for uranium was approximately 50 percent.

COCs removed from pit water would be deposited as sediment in pits. Under some conditions, the treatment may be reversible. For example, if the pit sediments became oxidized, uranium as insoluble U(IV) would be oxidized to soluble U(VI) and could be released into the water column.

Treatability testing would be required to select the treatment amendments and evaluate removal efficiencies for various contaminants, volumes of sediment produced, and sediment characteristics (e.g., under what conditions could COCs be released back into the water column).

5.3.5.6 Short-Term Effectiveness

Protection of Community and Workers. Considerations for protection of the community and workers are the same under Alternative 3d as described under Alternative 3c, with the exception the risks to workers and the community from water treatment and sludge hauling would be reduced.

Environmental Impacts. Potential short-term environmental impacts under Alternative 3d are generally similar to those described under Alternative 3c. In-situ treatment of MAA alluvial groundwater would mitigate the potential effects of groundwater collection on aquatic and riparian habitat that are described under Alternative 3c. Some potential exists for disturbance of habitat in areas downgradient of the MA where PRBs would be constructed. In-situ treatment of Pit 4 water may deplete oxygen in the pit water and potentially impact the limited amphibian community in the pit.

Time Until RAOs are Achieved. RAOs for surface materials and air would be achieved when cover construction is complete. An estimated 2 to 3 years would be required for development of cover materials sources and cover construction. MAA sediment response actions could be completed and sediment RAOs achieved within one year of completion of cover construction. To the extent access and use restrictions are effective, RAOs for protection of human health from exposure to MA surface water, groundwater, and sediment and MAA surface water, groundwater, surface water, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to MAA surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved at the completion of remedy construction. A recovery period that may be on the order of one to several decades may be needed to achieve these RAOs.

Under Alternative 3d, the time frame of one to several decades to achieve RAOs for ecological receptors indicates an ongoing short-term impact on tribal resources.

5.3.5.7 Implementability

Technical Feasibility. The primary technical implementability considerations under Alternative 3d relate to the ability to design and effectively operate PRBs and in-situ pit water treatment. Treatability studies would provide information to support design of PRBs and in-situ pit water treatment, including selection of reactive media and amendments.

Monitoring could effectively measure the success of Alternative 3d in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 3d would preclude additional remedial action, if it were needed in the future. Once a cover is in place, however, additional remediation that involves moving covered materials would be more costly.

Administrative Feasibility. As with other alternatives that result in sludge generation, a potential administrative feasibility consideration is the ability to meet the applicable or relevant and appropriate requirements of the Tribal HSCA for a new disposal facility for sludge and spent reactive media, if onsite disposal is used.

Compliance with the ESA may require consultation, a biological assessment, or other actions which could delay initiation of cleanup.

Offsite actions may require permits. Surface mining permits from Tribal, state, or local agencies may be required to excavate borrow materials. Potential difficulties in obtaining permits may delay implementation or increase costs. If offsite sludge disposal is used, a demonstration of no free liquids would be required to obtain a permit for disposal at the Richland facility.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require coordination with the BIA, as well as coordination and consultation with the Tribe.

Availability of Services and Materials. As described under Alternative 3c, the availability of suitable cover material is a primary implementability consideration under Alternative 3d.

PRBs can be constructed using readily-available conventional construction equipment. An estimated 25,000 tons of ZVI would be required for construction of PRBs. PRB construction may be limited by the availability of ZVI. For example, 25,000 tons of ZVI represents approximately 3 years of production for one large ZVI producer (Klein 2004). Therefore, the remedy implementation time could be affected by the availability of reactive media.

Chemicals for in-situ pit water treatment are typically applied from the shore using readily-available equipment such as hydroseeders. For FS analysis, it is assumed the amendments would consist of a mixture of lime, sugar, and ethanol B (75% ethanol and 25% propanol). For initial pit treatment, up to an estimated 570 tons of lime, 20 tons of sugar, and 80 tons of ethanol B may be required. For subsequent reapplication, up to an estimated 3.5 tons per year of sugar and 14 tons per year of ethanol B may be required. These materials would likely be available in adequate quantities.

Considerations related to the availability of offsite sludge disposal capacity are described under Alternative 2b. These concerns would be mitigated under Alternative 3d because the volume of sludge produced would be considerably lower. There are adequate sources of labor, equipment, and reagents to conduct active water treatment and dewater and solidify the sludge.

5.3.5.8 Cost

A range of costs has been estimated for Alternative 3d. The low range ("base" cost) was estimated assuming onsite disposal of sludge and reactive media. The high range ("base plus incremental" cost) was estimated assuming offsite disposal of sludge and reactive media at the Richland facility and increased thicknesses of protective covers. The estimated costs are summarized as follows.

- Estimated capital cost = $97,000,000 (base) to $103,000,000 (base + incremental)
- Estimated average annual O&M cost = $1,000,000 (base) to $1,300,000 (base + incremental)
- Total estimated present worth cost (7%, 30 years) = $123,000,000 (base) to $139,000,000 (base + incremental)
- Total estimated present worth cost (3.1%, 140 years) = $175,000,000 (base) to $218,000,000 (base + incremental)

Table 5-16 presents a breakdown of estimated costs under Alternative 3d. In addition to annual O&M costs, Alternative 3d includes significant period costs. These periodic costs include replacement and disposal of spent reactive media, reapplication of pit water amendments, and replacement of the WTP.

The primary capital cost uncertainties are related to the cost of providing suitable material for construction of protective covers, as discussed under Alternative 3c, and the cost of constructing PRBs. One vendor reported that the cost of ZVI nearly doubled in a year, increasing from approximately $400 per ton to approximately $800 per ton in April 2004 (Klein 2004). A ZVI cost of $800 per ton was used to estimate costs for Alternative 3d.

The primary O&M cost uncertainty is related to replacement and disposal of spent reactive media used in the PRBs. The O&M cost for replacement and disposal of spent reactive media will depend on the unit cost to obtain the media, the volume of media used, and its effective life. There is a considerable degree of uncertainty associated with each of these variables. This uncertainty could be reduced to some extent through treatability testing. The volume and effective life used to estimate costs for Alternative 3d were based on the design of a PRB at a site with similar COCs (Monticello, Utah site). In spite of these uncertainties, it is unlikely that PRBs would be cost-effective for treatment of all contaminated seep and groundwater flows compared to ex-situ treatment unless loads of COCs are lower than those estimated in this FS. PRBs could be cost-effective for treatment of smaller loads in groundwater.

As a result of these uncertainties, the estimated cost for Alternative 3d may not be within -30 percent to +50 percent. Treatability studies would be required to reduce the uncertainty.

A preliminary evaluation of costs for modifications to the WTP that may be needed to meet surface water RAOs is presented in Section 5.

5.3.6 Alternative 4d (Partial Pit Backfill and In-Situ Water Treatment)

5.3.6.1 Description

The primary elements of Alternative 4d include:

- Consolidation of the ore and protore stockpiles in Pit 3; the material would be amended with organic material, lime, and nutrients to effect in-situ water treatment in the pit
- Consolidation of approximately 300,000 cy of waste rock from the Hillside Dump in Pit 4; the material would be amended with organic material, lime, and nutrients to effect in-situ water treatment in the pit
- Regrading of other waste rock areas and placement of a thin cover, similar to Alternative 3c
- Regrading of the existing backfilled pits area and placement of a thin cover
- Construction of a stormwater management system
- Collection of seep water and MAA groundwater, including outflow from the backfilled pits where it emerges in the Central Drainage seeps and groundwater in MAA; this water would be injected into Pit 3 for treatment
- Excavation of contaminated soil in the haul roads and adjacent impacted areas; the soil would be consolidated with the ore and protore and placed in Pit 3
- Excavation of contaminated MAA sediments; the sediments would be consolidated with the ore and protore and placed in Pit 3
- Institutional controls, including use restrictions and information programs, and access controls
- Long-term monitoring and 5-year reviews

An overview summary of the elements of Alternative 4d is presented in Table 5-3. A summary of institutional controls included under Alternative 4d is presented in Table 5-4.

Alternative 4d includes partial backfilling of Pits 3 and 4 to a level that is above the water level in the pits, which would eliminate the pit lakes and the direct exposure pathways to contaminated pit water and sediment. Potentially reactive materials placed in the pits would be amended, as described below, to reduce contaminant mobility.

Pit 3 would be partially backfilled with ore, protore, and waste rock. Pit 4 would be partially backfilled with waste rock. The pits would be covered to reduce radon flux and surface water percolation. Waste rock that is not placed in the open pits, including the existing backfilled pits area, would be regraded to a maximum side slope of 3H:1V and covered, as described under Alternative 3c. A conceptual cover plan for Alternative 4d is shown in Figure 5-8. Activities that could compromise the integrity of the cover, including residential use, excavation, and motorized vehicle use, would be prohibited within the cover area. Because concentrations of COCs in groundwater beneath the MA would not be reduced to protective levels within the foreseeable future, installation of groundwater wells within the MA would be prohibited. Access to the open pit highwalls would be restricted by a fence.

Under Alternative 4d, potentially reactive material would be amended with organic material, lime, and any necessary nutrients and placed in the lower elevations of the pits, as shown conceptually for Pit 3 in Figure 5-9. The potentially reactive material would be covered with a layer of non-reactive waste rock from the site. The water level would be maintained within the non-reactive waste rock layer, which would limit oxygen diffusion into the reactive materials. The pits would be covered to reduce percolation, but groundwater would be able to migrate laterally through the amended waste material, including into and out of the pits, to the extent outflow into fractured bedrock occurs.

The amendments added to the reactive waste materials, together with the reduced oxygen diffusion into the reactive materials, would reduce contaminant mobility. Dissolution of the lime would neutralize acidity generated by sulfide minerals, thereby raising the pH of the groundwater and limiting dissolution of metals and radionuclides into the groundwater. The organic material would serve as a carbon and energy source for naturally-occurring microorganisms, which should result in anoxic conditions and growth of sulfate-reducing bacteria. The sulfate-reducing bacteria would catalyze beneficial reactions that result in the precipitation of dissolved metals as insoluble sulfide minerals in an anoxic environment.

Creation of anoxic conditions would potentially have other beneficial effects in addition to precipitation of metals as sulfides. Anoxic conditions would limit the mobility of uranium in groundwater. Uranium in a reduced state (U[IV], which would occur in anoxic conditions, has low solubility, whereas uranium in an oxidized state (U[VI]) is soluble even in circumneutral water. Anoxic conditions also would limit precipitation of iron oxyhydroxides, which tend to coat and reduce the effectiveness of the lime amendments.

Even in anoxic conditions, production of acid could occur due to the presence of sulfur-oxidizing bacteria and the oxidation of pyrite by ferric iron (Fe^{3+}). However, the solubility of ferric iron decreases rapidly as pH increases. Therefore, increasing the pH through lime addition would limit acid production caused by ferric iron oxidation of pyrite.

If these effects occur as assumed, the pits would act as in-situ bioreactors that could limit dissolution of contaminants and remove dissolved metals and radionuclides from groundwater. (In the following discussions, the partially backfilled pits are referred to as "pit bioreactors.") Contaminated water, including water that is collected at the seeps and MAA groundwater, would be injected into Pit 3 for treatment, and active water treatment and generation of sludge would be reduced or eliminated. The injection wells would be placed at the upgradient end of the pits and screened throughout the total thickness of the amended reactive material layer to achieve thorough mixing. Runoff from the highwalls would be allowed to percolate into the pits for treatment.

Treatability studies would be required to evaluate the design and effectiveness of the neutralization and precipitation process. The concept has been applied in the field in a PRB. At the Nickel Rim site, a mixture of 20% municipal compost, 20% leaf mulch, 9% wood chips, 50% gravel, and 1% limestone was effective at reducing concentrations of nickel and sulfate and increasing alkalinity (Benner et al. 1999). Given the very large size of the pits, it would not be practical to amend the waste with organic material at the high percentage used at Nickel Rim. For FS analysis, it is assumed the amendments would consist of lime, wood waste, compost, and nutrients in adequate quantities to conduct in-situ treatment for a minimum of 30 years. The estimated quantities include 30,000 tons of lime and 330,000 tons of organic material (Appendix C). Calc-silicate materials stockpiled on site may provide a source of lime; however, preprocessing (crushing) might be required if these materials were used. For FS analysis, it is assumed lime would be imported from a commercial source rather than relying on the lime in the calc-silicate waste materials. Should the process prove effective, it is probable that additional injections of lime, organic material, and/or nutrients would be required after approximately 30 years when the initial amendments are exhausted.

Because pumping of water from the pits would be discontinued, seep water and MAA groundwater would be injected into Pit 3, and groundwater inflow would continue, the groundwater levels in the pits would rise. The long-term static groundwater elevation within the pits after backfilling would likely be controlled by the lowest bedrock surface elevation at the perimeter of the pit (i.e., the pit would fill until groundwater "spilled" over the bedrock "lip," which has elevations of approximately 2700 feet above msl in Pit 3 and 3060 feet above msl in Pit 4). To maintain the water level below the bedrock lip, the long-term static groundwater elevation in the pits would be controlled by constructing a drainage system. For FS analysis, it is assumed Pit 3 would be backfilled with reactive material to an elevation of 2650 feet above msl and with non-reactive waste rock to a total elevation of 2670 feet above msl. A drainage system would be used to maintain a maximum water elevation of 2660 feet above msl (the water level currently fluctuates between approximately 2550 and 2570 feet above msl). It is assumed Pit 4 would be backfilled with reactive material to an elevation of 3030 feet above msl and with non-reactive waste rock to a total elevation of 3050 feet above msl. A drainage system would be used to maintain a maximum water elevation of 3040 feet above msl (the water level currently fluctuates between approximately 2990 and 3020 feet above msl). An open channel or culvert

would be excavated that would convey outflow from the pits to the Eastern Drainage. The channel or culvert would be designed to create water turbulence that would naturally reoxygenate the water.

The volume of material required to backfill Pit 3 to an elevation of 2670 feet above msl is approximately 2.4 million cy. The volume of material required to backfill Pit 4 to an elevation of 3050 feet above msl is approximately 300,000 cy. Estimated backfill volumes and backfill footprint areas for various elevations in Pit 3 are shown in Table 5-17.

Because there are no treatability data for the pit bioreactors, it is uncertain whether the treated pit water would be suitable for direct discharge to surface water[15]. Accordingly, a cost contingency has been included for further treatment of water from the pit bioreactors using the WTP. In addition, some outflow from the pits into the fractured bedrock would occur. The ability of the pit bioreactors to meet groundwater quality RAOs and the magnitude of outflow into fractured bedrock would need to be evaluated further before implementation of Alternative 4d. Following implementation, long-term monitoring would be required to evaluate whether the treated pit water quality is suitable for discharge or if additional treatment is necessary.

Alternative 4d includes expanded collection and treatment of MAA groundwater. This element of Alternative 4d was added after the alternatives screening step. In addition to the existing seep collection points, the expanded water collection includes:

- Groundwater collection trenches near the locations of the existing seep collection points
- Groundwater collection in areas further downgradient, where groundwater discharges to the Western, Central, and Eastern Drainages

These measures are described in detail under Alternative 3c. The collected MAA groundwater would be conveyed to Pit 3 for in-situ treatment.

Collection of alluvial groundwater would affect groundwater levels and base flows in the MAA drainages, which could have adverse effects on aquatic and riparian habitat. These effects, should they occur, could be mitigated by reintroducing clean runoff or treated water into the alluvial aquifer through infiltration trenches or injection wells.

Alternative 4d includes excavation of mining-related instream sediments in the MAA drainages. Sediment removal would not be conducted in areas where such measures would cause unacceptable adverse impacts to existing ecosystem habitats. Sedimentation dams and traps would be constructed at selected locations in the drainages to capture and contain contaminated sediment and control downstream transport during excavation activities. Riparian areas that are

[15] In addition to the potential for elevated levels of COCs, the possibility exists that the treated water could contain unacceptable levels of nutrients or organic acids.

disturbed during sediment removal activities would be revegetated. To limit the potential for recontamination, these actions typically would be implemented after source control within the MA was complete.

Contaminated materials on and adjacent to the East Haul Road, West Haul Road, Western Drainage Access Road, and Central Drainage Access Road would be excavated and disposed of on site with the ore and protore materials. Assuming the haul and access roads would be excavated to an average depth of 2 feet and areas adjacent to the East and West Haul Roads would be excavated to an average depth of 1 foot, the estimated volume of material that would be excavated is 56,000 cy.

A potential staging of construction activities is as follows:

- Ore and protore would be temporarily stockpiled in a central location and provided with a temporary cover. Cover materials and amendments (lime and organic material) would be imported and stockpiled.
- Other areas of the MA would be provided with a permanent cover to reduce subsequent flows of contaminated runoff and seep water that would require treatment; concurrently, Pit 4 would be backfilled and covered. Pit 3 would be used for temporary contaminated water storage during this period.
- Starting when the high seep discharge period associated with spring runoff ends, Pit 3 would be dewatered.
- Pit 3 would be partially backfilled with amended ore and protore, then backfilled to final grade with waste rock.
- A permanent cover would be constructed over the backfilled part of Pit 3 and the temporary stockpile area.
- Cleanup actions for drainage sediments would be implemented.
- A period of monitoring would be conducted to evaluate the need for and locations of MAA groundwater collection wells.
- MAA groundwater collection wells would be installed, as needed.

It is estimated that implementation of Alternative 4d, not including the monitoring period and construction of MAA groundwater wells, would require approximately five to six years.

5.3.6.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. Ore, protore, and waste rock would be contained under a protective cover that would eliminate the direct ingestion pathway, reduce radon flux to the NESHAPs and UMTRCA standard (20 $pCi/m^2/s$), and reduce external radiation to protective levels. Land use limitations and periodic inspections and maintenance would be required to ensure the integrity of the cover. Considerations related to regrading and construction of covers are the same as described under Alternative 3c.

Surface Water and Sediment in Open Pits. Under Alternative 4d, the open pits would be backfilled to above the water level in the pits. This action would eliminate the surface water and sediment exposure pathways in the open pits, with the exception of runoff from the pit highwalls, which would be collected and treated in the pit bioreactors, if necessary.

Groundwater Within the MA. Under Alternative 4d, use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. The use restrictions would be needed for the foreseeable future. Contaminated groundwater, including outflow from the existing backfilled pits, would be collected where it leaves the MA in seeps and alluvial groundwater and conveyed to the pit bioreactors for treatment. Collection and treatment of alluvial groundwater would further reduce the transport of contaminants from MA groundwater to surface water compared to existing conditions.

Groundwater and Surface Water in Mine Drainages and Blue Creek. Alternative 4d would improve groundwater and surface water quality compared to existing conditions by containing ore, protore, and some waste rock in a reducing environment that would limit mobilization of COCs. Alternative 4d would also reduce contact of water and oxygen with other waste rock using a soil cover. Contaminated seep water and groundwater, including any outflow from the existing backfilled pits that may occur, would be collected where it emerges in the MAA and treated in the pit bioreactors. The results of these actions are expected to include:

- Stream flows in the Western Drainage and Central Drainage would be enhanced because an estimated average of 22,000,000 gallons per year of runoff water would be isolated from ore, protore, and waste rock within the MA and conveyed to the drainages as clean water.

- Water treatment requirements and the potential for releases of contaminated water would be reduced because the estimated volume of contaminated seep water would be reduced from an average of approximately 44,000,000 gallons per year to an estimated average of 14,000,000 gallons per year as a result of source containment measures.

- Surface water quality in the drainages would be improved because discharge of contaminated groundwater to the drainages would be reduced from an estimated average of 17,000,000 gallons per year to an estimated average of 4,000,000 gallons per year.

- Use of in-situ treatment would reduce loads of sulfate released to the surface water system. Disposal of ore, protore, and some waste rock in the pits in a reducing environment should limit production of sulfates from these materials. Treatment of contaminated seep water in the pits should result in a higher degree of sulfate removal from this water than is achieved by the existing active treatment system.

As a result of these source control and water treatment actions, the estimated average uranium load in the Eastern Drainage under Alternative 4d would be reduced to approximately 33 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1 (Appendix F). This analysis assumes additional water treatment would be conducted if the discharge from the pits does not meet surface water RAOs. This limited analysis suggests that the average uranium concentration in Blue Creek may be reduced to the background concentration over time.

Surface water and groundwater quality in the mine drainages may also approach background conditions over time. It is anticipated a longer recovery period would be needed for the mine drainages than for Blue Creek. The recovery period may be on the order of one to several decades. To the extent surface water and groundwater contain COCs at concentrations that exceed protective levels after implementation of Alternative 4d, use restrictions and information programs would be included to limit exposures.

Treatment residuals would be reduced or eliminated under Alternative 4d. In-situ treatment in the pit bioreactors could prove to be less effective and reliable for removing COCs over the long term than the existing active treatment system, and there would be some potential for remobilization of COCs, should conditions in the pits change over time.

Sediment in Mine Drainages and Blue Creek. Sediment quality in MAA drainages generally would continue to improve over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas. This natural recovery process would be supplemented by excavation of contaminated sediments under Alternative 4d. These actions would limit exposure of humans and animals to concentrations of COCs and risk drivers that exceed background levels. Some short-term sediment quality impacts would likely occur as

a result of these excavation activities and remedy construction activities within the MA; however, these impacts could be limited through use of sediment control BMPs.

Haul Roads Soil. Under Alternative 4d, exposure to contaminated soil within and adjacent to the haul roads would be reduced to protective levels by excavating the contaminated material and disposing of it together with the ore and protore in Pit 3.

Plant and Animal Tissue. Under Alternative 4d, a soil cover would be used to reduce uptake of COCs by plants and animals within the MA. The soil cover should reduce concentrations of COCs in terrestrial plants in the MA to background levels, which would allow these plants to be safely consumed by livestock or other animals. In addition, the cover should reduce uptake of COCs in animal tissue through consumption of these plants to background levels.

Containment and treatment actions in the MA implemented under Alternative 4d would improve surface water and sediment quality within the MAA, which would reduce uptake of COCs by plants and animals. Sediment removal actions in the MAA drainages would further reduce uptake of COCs by plants and animals. Information programs would be implemented to reduce human ingestion of contaminated plant and animal tissue from the MAA, including Blue Creek, until background concentrations of COCs in surface water and sediment are achieved.

Summary. In summary, Alternative 4d would provide protection of human health and the environment. Institutional controls would be used to reduce human exposure to surface water and groundwater in the MAA until background concentrations of COCs were achieved. Protection of the environment would also be provided when background concentrations of risk drivers in MAA surface water were achieved. It is anticipated that a recovery period that may be on the order of one to several decades would be required to achieve background concentrations in MA surface water and groundwater. Restrictions on groundwater use within the MA would be needed for the foreseeable future.

5.3.6.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum

concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations.

Under Alternative 4d, loads of COCs and risk drivers discharged to Blue Creek and the mine drainages would be further reduced through source containment and expanded groundwater collection and treatment. As a result, concentrations of these contaminants may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. The time frame for Blue Creek would be shorter than for the mine drainages.

The concentrations of some constituents in the WTP effluent, including uranium, manganese, and sulfate, currently exceed Tribal water quality standards and background. Under Alternative 4d, contaminated water would be treated in the pit bioreactors; however, additional treatment in the WTP may be needed to meet surface water discharge ARARs. Should additional treatment be needed, treatability studies would be needed to determine what modifications would need to be made to the WTP to further reduce concentrations of these constituents to meet water quality ARARs. As discussed in Section 5.3.1.4, EPA is continuing to work with the Tribe to determine discharge requirements for sulfate. A preliminary evaluation of potential costs to treat sulfate to a concentration of 250 mg/L or lower is presented in Section 5.5.

Groundwater. Under Alternative 4d, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 262 acres). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations.

Alternative 4d includes source containment and expanded groundwater collection and treatment, which should prevent further migration of the plume and improve groundwater quality compared to current conditions. Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that

comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades.

Within the WMA, Alternative 4d includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 4d, areas with concentrations of COCs that exceed ARARs would be covered (within the MA) or excavated (haul roads and adjacent areas), which would result in compliance with potential ARARs for surface materials. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 4d, areas with concentrations of COCs that exceed ARARs would be excavated and disposed of in the existing open pits, which would result in compliance with potential ARARs for sediment.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Protective covers installed within the MA under Alternative 4d would reduce radon flux to levels that comply with the 40 CFR 61 standard.

Waste Management. Disposal of ore, protore, and waste rock in the open pits would meet the substantive requirements of RCRA Subtitle D. Since the ore, protore, and waste rock are Bevill-exempt materials, RCRA Subtitle C would not be an ARAR. Because these materials are byproducts of mining operations that are naturally occurring and not concentrated or chemically altered by human processes, Section 34-1.12 (Disposal of Hazardous Substances) of the Tribal HSCA would not apply.

If additional water treatment in the WTP is necessary and onsite disposal of treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. Alternative 4d would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

5.3.6.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 4d to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and treatment residuals at the conclusion of remedial activities under Alternative 4d are evaluated in this section.

Surface Water and Groundwater. Under Alternative 4d, uranium loads in the Eastern Drainage would be reduced to an estimated 33 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, would be reduced under Alternative 4d. Risks would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit use, risks could be reduced to protective levels.

Under Alternative 4d, risks from exposure to surface water in the open pits would be eliminated. Risks from exposure to groundwater in the pits could be reduced to protective levels through institutional controls that would prohibit use of the pit groundwater.

Sediment. Risks from exposure to sediment in the open pits would be eliminated. Risks from exposure to COCs in sediment in the drainages and Blue Creek would decline from current levels as a result of source controls in the MA and excavation of contaminated sediment. Some risk would remain in areas where sediments are not excavated due to potential adverse ecological impacts; however, risks likely would be reduced to protective levels over time.

Surface Materials. Risks from exposure to external radiation and COCs in surface materials would be reduced to acceptable levels, as long as the integrity of the cover system is maintained.

Air. The areawide average radon flux in the MA would be reduced from approximately 50 $pCi/m^2/s$ to 20 $pCi/m^2/s$ or less. The flux level of to 20 $pCi/m^2/s$ was adopted in NESHAPs and UMTRCA for radon source areas (e.g., the MA) to provide acceptable risk levels for residential use in adjacent areas (e.g., the MAA). Land use restrictions that limit used of the covered areas to transient foot traffic would be used to reduce risks from radon inhalation within the MA following attainment of the 20 $pCi/m^2/s$ standard.

Treatment Residuals. Assuming the pit bioreactors reduce concentrations of COCs in water to acceptable levels, no treatment residuals would be produced under Alternative 4d. If additional ex-situ treatment of is needed, risks from potential exposure to water treatment sludge (estimated average of 110 tons per year) would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 4d.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage residual risks under Alternative 4d, including pit bioreactors, sediment excavation, and other controls, are evaluated in this section.

Pit Bioreactors. There is limited existing information available to evaluate the adequacy and reliability of pit bioreactors. The Nickel Rim site was orders of magnitude smaller than the open pits; thus, its performance may not accurately predict the performance of the pit bioreactors. Treatability studies would be needed to evaluate the potential performance of the pit bioreactors. If removal of COCs is inadequate and the pit water is not suitable for discharge, additional treatment in the active system would be required prior to discharge. In addition, some potential for remobilization of accumulated COCs would exist if conditions in the pit change. For example, uranium may be remobilized if the groundwater in the pit becomes oxygenated. Ongoing monitoring of the system would be required to evaluate the adequacy of the treatment.

Water would have a long residence time in the pit bioreactors. For water elevation of 2,660 feet above msl in Pit 3, assuming a porosity of 30% and a treatment rate of 31 million gallons per year, the average residence time would be approximately four years. This residence time would be more than adequate for microbial sulfate reduction and metal sulfide precipitation to take place. Some potential for flow short-circuiting would exist; however, the large volume of the pit should limit the impact of short-circuiting. Problems experienced with biological systems at high elevations due to cold temperatures would not be a concern because the groundwater temperature would not fluctuate significantly.

The pit amendments would be consumed over time, and additional amendments may be required (for FS analysis, it is estimated the amendments would last for 30 years). Additional amendments would be injected as liquids using injection wells. These wells, which also would be used to inject contaminated seep water for treatment, may become clogged over time and require maintenance to restore their capacity.

Sediment Excavation. Excavation of instream sediments would be permanent and reliable. Mobilization of sediment during excavation activities could be limited by working during periods when stream flows are low or non-existent and by using sediment control measures such as silt fences. The potential for recontamination could be limited by removing sediments after remedy construction within the MA has been completed.

Other Controls. The adequacy and reliability of controls including protective covers, water collection wells and trenches, stormwater management systems, and institutional controls would be the same as described under Alternative 3c.

Summary. Under Alternative 4d, residual risks to tribal members and tribal resources would be reduced from current conditions. However, residual risks would continue to be posed by contaminants in surface materials, surface water, and groundwater. Risks from these media would be managed through use of access and institutional controls. These controls includes restrictions on the open pit high walls, WTP (3 acres), cover areas (310 acres), and sludge disposal site, if any (2 acres). Reliance on access and institutional controls and information programs lacks certainty at this site due to regulatory context (e.g., limited Tribal mechanisms, allottee rights, and federal jurisdiction).

Alternative 4d would require some periodic reapplication of material to in-situ pit and some ex-situ water treatment. To the extent that such actions are needed, this would necessitate long-term funding, operation, and maintenance.

5.3.6.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under Alternative 4d, the toxicity of seep water, highwall runoff water, and pit groundwater would be reduced through in-situ treatment in Pit 3 and Pit 4, using addition of lime and organic amendments. The toxicity of an estimated average of 37,000,000 gallons per year of contaminated water would be reduced. The achievable effluent concentrations will vary depending on the contaminant.

No treatment residuals would be produced; contaminants would be sequestered within the pit backfill. Under some conditions, the treatment may be reversible. For example, if the pit groundwater became oxidized, uranium would be oxidized and could be released into the pit groundwater.

Treatability testing would be required to select the treatment amendments and evaluate removal efficiencies for various contaminants, whether treated groundwater concentrations would be low enough to permit discharge without further treatment, and the long-term effectiveness of the treatment.

5.3.6.6 Short-Term Effectiveness

Protection of Community and Workers. Under Alternative 4d, considerations for protection of the community and workers would not differ substantially from those described under Alternative 3c, with the exception that risks to workers and the community from water treatment and sludge hauling would be reduced.

Environmental Impacts. Potential short-term environmental impacts under Alternative 4d are generally similar to those described under Alternative 3c. Potential short-term impacts would also result from sediment removal actions in riparian areas within the drainages. Engineering controls such as sediment fencing, sediment traps, revegetation, and biostabilization measures would be used to limit these impacts.

Time Until RAOs are Achieved. RAOs for surface materials and air and MA surface water and sediment would be achieved when cover construction is complete. An estimated four to five years would be required for development of cover materials sources, conducting treatability studies and obtaining suitable amendments for the pit bioreactors, partial backfilling of the open pits, and cover construction. MAA sediment response actions could be completed and sediment RAOs achieved within one year of completion of cover construction. To the extent access and use restrictions are effective, RAOs for protection of human health from exposure to MA groundwater and MAA surface water, groundwater, surface water, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to MAA surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved at the completion of remedy construction. A recovery period that may be on the order of one to several decades may be needed to achieve these RAOs.

Under Alternative 4d, the time frame of one to several decades to achieve RAOs for ecological receptors indicates an ongoing short-term impact on tribal resources.

5.3.6.7 Implementability

Technical Feasibility. The primary technical implementability considerations under Alternative 4d relate to the ability to design and effectively operate the pit bioreactors. No other mine sites where pit bioreactors have been implemented on the same scale have been identified. Treatability studies would provide information to support design of the pit bioreactors, including selection of suitable amendments.

An additional consideration is the ability to segregate adequate quantities (estimated 500,000 cy) of non-reactive waste rock needed for the upper layer of the pit backfill. This material is intermixed with unsuitable waste rock, and segregation of suitable material could slow earthwork operations.

Monitoring could effectively measure the success of Alternative 4d in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 4d would preclude additional remedial action, if it were needed in the future. Should in-situ treatment prove ineffective, active water treatment, as is currently employed at the site, could be resumed. Extraction wells could be installed in the pit backfill to extract groundwater and treat it in the active treatment plant, if necessary. However, the extraction wells and water treatment would require long-term O&M, and the additional cost of the amendments would have been unnecessary.

Administrative Feasibility. Compliance with the ESA may require consultation, a biological assessment, or other actions which could delay initiation of cleanup.

Offsite actions may require permits. Surface mining permits from Tribal, state, or local agencies may be required to excavate borrow materials. Potential difficulties in obtaining permits may delay implementation or increase costs.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require extensive coordination with the BIA, as well as coordination and consultation with the Tribe.

Availability of Services and Materials. As described under Alternative 3c, the availability of suitable cover material is a primary implementability consideration for Alternative 4d.

Waste materials placed in the pits would be amended with an estimated 30,000 tons of lime. It is not known if onsite calc-silicate materials could be economically processed to provide this lime. “Dirt lime” is a byproduct of sugar production and is available in adequate quantities from facilities in Nampa, Idaho and Nyssa, Oregon. The closest supplier of commercial lime is located in Montana. This facility is capable of producing 300 tons per day of hydrated lime (Graymont 2004). If a commercial source of lime is used, the availability of lime could limit the rate at which the pits could be backfilled.

Waste materials placed in the pits would be amended with an estimated 330,000 tons of organic material (wood waste and compost). Potential large sources of these materials include sawdust from saw mills, yard waste from Spokane County, biosolids from Spokane County wastewater treatment, and vendors of organic material. The future availability of these materials is not known at this time. One vendor reported that 100,000 tons of compost could be provided over a

period of 24 months (Davis 2004). The availability of suitable organic material could limit the rate at which the pits could be backfilled.

To the extent in-situ water treatment achieves RAOs, considerations regarding the availability of disposal sites for water treatment sludge, which are described under Alternative 2b, may be reduced or eliminated under Alternative 4d.

5.3.6.8 Cost

A range of costs has been estimated for Alternative 4d. The low end of the range ("base" cost) was estimated assuming water treatment in the pit bioreactors only. The high end of the range ("base plus incremental" cost) was estimated assuming the effluent from the pit bioreactors would require further treatment using the WTP, with offsite sludge disposal at the Richland facility, and increased thicknesses of protective covers. The estimated costs are summarized as follows.

- Estimated capital cost = $106,000,000 (base) to $114,000,000 (base + incremental)
- Estimated average annual O&M cost = $880,000 (base) to $1,900,000 (base + incremental)
- Total estimated present worth cost (7%, 30 years) = $116,000,000 (base) to $136,000,000 (base + incremental)
- Total estimated present worth cost (3.1%, 140 years) = $135,000,000 (base) to $177,000,000 (base + incremental)

Alternative 4d also includes periodic costs for reapplication of pit bioreactor amendments. Table 5-18 presents a breakdown of estimated costs under Alternative 4d.

The primary capital cost uncertainties are related to the cost of providing suitable material for construction of protective covers, as discussed under Alternative 3c, and the cost of obtaining suitable amendments for use in the pit bioreactors.

The primary O&M cost uncertainties are related to the need to further treat water discharged from the pit bioreactors. If further treatment is required, these uncertainties include the method of water treatment sludge disposal (onsite or offsite) and any modifications to the water treatment system that may be needed to meet discharge RAOs.

5.3.7 Alternative 4e (Partial Pit Backfill with Passive Drains and Ex-Situ Water Treatment)

5.3.7.1 Description

Alternative 4e includes institutional controls, containment of ore, protore, and some waste rock in the open pits (partial backfill), in-place containment of other waste rock, and collection of contaminated seep and MAA groundwater (including outflow from the backfilled pits where it emerges in seeps and groundwater in MAA), as described under Alternative 4d. The primary elements of Alternative 4d incorporated in Alternative 4e include:

- Consolidation of the ore and protore stockpiles in Pit 3
- Consolidation of waste rock from the Hillside Dump in Pit 4
- Regrading of other waste rock areas and placement of a thin cover, similar to Alternative 3c
- Regrading of the existing backfilled pits and placement of a thin cover
- Construction of a stormwater management system
- Collection of seep water and MAA groundwater, including outflow from the backfilled pits where it emerges in the Central Drainage seeps and groundwater
- Excavation of contaminated soil in the haul roads and adjacent impacted areas; the soil would be consolidated with the ore and protore and placed in Pit 3
- Excavation of contaminated MAA sediments; the sediments would be consolidated with the ore and protore and placed in Pit 3
- Institutional controls, including use restrictions and information programs, And access controls
- Long-term monitoring and 5-year reviews

Alternative 4e differs from Alternative 4d in three primary elements:

- Passive drains would be installed in the bases of Pit 3 and Pit 4 to maintain the groundwater level below the reactive materials, which is intended to reduce impacts to groundwater in the pits
- The waste materials placed in the pits would not be amended
- Contaminated water would be treated ex-situ in the WTP rather than in-situ in pit bioreactors

An overview summary of the elements of Alternative 4e is presented in Table 5-3. A summary of institutional controls included under Alternative 4e is presented in Table 5-4. A conceptual cover plan for Alternative 4e is shown in Figure 5-10.

After dewatering the pits, contaminated pit sediments would be excavated and consolidated with the ore and protore. A water collection sump would be excavated in the pit floor. A 5-feet thick layer of non-reactive rock would be placed on the pit floor and against the highwall to the top of the backfill to act as a drainage blanket and direct groundwater to the sump. For FS analysis, it is assumed the drainage blanket could be constructed using non-reactive waste rock (approximately 190,000 cy total for the two pits). Water that collects in the sump would drain out by gravity in a lined, horizontal borehole.

Pit 3 would be backfilled with ore and protore to an elevation of approximately 2640 feet above msl and covered with a thick cover to reduce surface water percolation and radon flux. Pit 4 would be backfilled with waste rock to an elevation of approximately 3040 feet above msl and covered with a thin cover to reduce surface water percolation and radon flux. A geotextile would be placed over the drainage blanket to separate the drainage blanket from the waste material backfill. A conceptual cross section of Pit 3 after backfilling under Alternative 4e is shown in Figure 5-11.

For FS analysis, it is assumed the passive drain from Pit 3 would be bored along a south-southwest alignment from the Pit 3 sump to the Western Drainage south of the MA. A drain bored on this alignment likely would encounter both monzonite and rock of the Togo Formation (the Togo Formation is more likely to contain reactive rock than the monzonite). Based a grade of 2 percent for drainage, the drain outlet would be located approximately 500 feet south of the southern boundary of the MA. The drain length would be approximately 3,500 feet. A potential alternate alignment would run south-southeast from Pit 3 to the Eastern Drainage south of the MA. A drain bored on this alignment likely would encounter the Togo Formation for most of its length. The locations of the alignments are shown in Figure 5-11. Cross sections showing generalized geologic conditions along the potential drain alignments are shown in Figures 5-12 and 5-13.

For FS analysis, it is assumed the passive drain from Pit 4 would be bored along a east-southeast alignment from Pit 4 to the Northeastern Drainage east of the MA. The total length of the drain would be approximately 1,500 feet, and its outlet would be located approximately 900 feet east of the MA boundary (Figure 5-11). A drain bored on this alignment would probably encounter the Togo Formation for most of its length.

It is anticipated that the discharge from the drains would contain COCs at concentrations that exceed water quality standards or background. Therefore, it is assumed the discharge would be collected and conveyed to the WTP for treatment.

Where the drain intersects sulfide-bearing rock, the potential would exist for leaching of contaminants if water and oxygen are present. In addition, groundwater may leak into the drain, which could increase water treatment requirements, or leak out of the drain, which could impact groundwater. The drain would be lined to limit these effects. Because the diameters of the boreholes (assumed to be 8 inches) would be very small compared to their lengths, air flow through the boreholes would be limited.

Some potential would exist for the passive drains to fail to function as designed. If the drains should fail, the groundwater level could rise into the waste materials, and poor quality groundwater could collect within the pits. To prevent this, groundwater extraction wells could be installed should the passive drains fail.

Alternative 4e includes the same response actions for MAA groundwater, contaminated haul road soils, and drainage sediments as those described under Alternative 4d. Collection and treatment of MAA groundwater was added to Alternative 4e after the alternatives screening step.

A potential staging of construction activities is as follows:

- Ore, protore, and haul road soil would be temporarily stockpiled in a central location and provided with a temporary cover. Cover materials would be imported and stockpiled.
- Other areas of the MA would be provided with a permanent cover to reduce subsequent flows of contaminated runoff and seep water that would require treatment.
- Starting when the high seep discharge period associated with spring runoff ends, Pits 3 and 4 would be dewatered. After dewatering is complete, drains would be constructed in Pit 3 and Pit 4.
- Pits 3 and 4 would be backfilled to grade, and permanent covers would be constructed over the pits and the temporary stockpile area.
- Cleanup actions for drainage sediments would be implemented.
- A period of monitoring would be conducted to evaluate the need for and locations of MAA groundwater collection wells.
- MAA groundwater collection wells would be installed, as needed.

It is estimated that implementation of Alternative 4e, not including the monitoring period and construction of MAA groundwater wells, would require approximately four to five years.

Collection and treatment of contaminated site water at rates similar to current rates would be required throughout the construction period until cover construction is complete. Since Pit 3 would be backfilled, collected seep water and stormwater would be routed directly to the WTP or to a new storage pond. The WTP and the pumpback system would be upgraded to permit year-

round operation. If offsite sludge disposal is used, temporary onsite sludge storage or year-round sludge hauling would be required.

Depending on remedy staging and seepage rates, a storage pond for untreated water may be required. It is anticipated that seep flows may exceed the 500 gpm capacity of the treatment plant after the cover system is installed during periods of very heavy precipitation or snowmelt runoff. In addition, temporary water storage may be needed during periods when the plant is not operational (for example, for maintenance). For FS analysis, it is assumed a lined untreated water storage pond would be constructed on top of the Pit 3 backfill.

For this FS, costs have been developed for both onsite and offsite sludge disposal. Onsite and offsite sludge disposal are described in Section 5.3.1.4. Under both disposal options, it is assumed for FS analysis that the sludge would be further dewatered using a frame filter press and solidified. As described in Appendix C, the estimated average future water treatment rate is approximately 38 million gallons per year, and the estimated average future sludge generation is 220 tons per year after dewatering. Based on a dewatered sludge density of 84 pound per cubic foot and assuming a volume increase of 10% due to solidification, the estimated average volumetric sludge generation rate is 5,800 cubic feet per year.

If onsite disposal is used, it is assumed for FS analysis that the facility would be constructed with a 100-year capacity. Based on an estimated volumetric sludge generation rate of 6,000 cubic feet per year, the required disposal facility capacity would be 600,000 cubic feet (22,000 cy). For an assumed average waste thickness of 20 feet, the disposal facility footprint would be about 1 acre.

5.3.7.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. The evaluation of protection of human health and the environment for MA surface materials, including external radiation and airborne radon, is the same as under Alternative 4d.

Surface Water and Sediment in Open Pits. Under Alternative 4e, the open pits would be backfilled to above the water level in the pits. This action would eliminate the surface water and sediment exposure pathways in the open pits, with the exception of runoff from the pit highwalls, which would be collected and treated in the WTP, if necessary. However, if contaminated water flows exceed the capacity of the treatment system, it would be necessary to provide a

contaminated water storage pond. Such a pond would be a potential source of exposure to contaminated surface water and sediment, similar to the existing pit lakes.

Groundwater Within the MA. Under Alternative 4e, use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. The use restrictions would be needed for the foreseeable future. Contaminated groundwater, including outflow from the existing backfilled pits, would be collected where it leaves the MA in seeps and alluvial groundwater and conveyed to the WTP for treatment. Collection and treatment of alluvial groundwater would further reduce the transport of contaminants from MA groundwater to surface water compared to existing conditions.

Groundwater and Surface Water in Mine Drainages and Blue Creek. Alternative 4e would improve groundwater and surface water quality compared to existing conditions by reducing contact of water and oxygen with ore, protore, and some waste rock by containing this material above the waters level in the existing open pits, which would be passively drained. Alternative 4e would also reduce contact of water and oxygen with other waste rock using a soil cover. Contaminated seep water and groundwater, including any outflow from the existing backfilled pits that may occur, would be collected where it emerges in the MAA and treated in the WTP. The results of these actions are expected to include:

- Stream flows in the Western Drainage and Central Drainage would be enhanced because an estimated average of 22,000,000 gallons per year of runoff water within the MA would be isolated from ore, protore, and waste rock and conveyed to the drainages as clean water.
- Water treatment requirements and the potential for releases of contaminated water would be reduced because the estimated volume of contaminated seep water would be reduced from an average of approximately 44,000,000 gallons per year to an estimated average of 15,000,000 gallons per year.
- Surface water quality in the drainages would be improved because discharge of contaminated groundwater to the drainages would be reduced from an estimated average of 17,000,000 gallons per year to an estimated average of 4,000,000 gallons per year.

As a result of these source control and water treatment actions, the estimated average uranium load in the Eastern Drainage under Alternative 4e would be reduced to approximately 21 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1 (Appendix F).

This limited analysis suggests that the average uranium concentration in Blue Creek may be reduced to the background concentration over time. To the extent surface water and

groundwater contain COCs at concentrations that exceed protective levels after implementation of Alternative 4e, use restrictions and information programs would be included to limit exposures.

Sediment in Mine Drainages and Blue Creek. The evaluation of protection of human health and the environment for sediment in the mine drainages and Blue Creek is the same as under Alternative 4d.

Haul Roads Soil. The evaluation of protection of human health and the environment for haul roads soil is the same as under Alternative 4d.

Plant and Animal Tissue. The evaluation of protection of human health and the environment for plant and animal tissue is the same as under Alternative 4d.

Summary. In summary, Alternative 4e would provide protection of human health and the environment. Institutional controls would be used to reduce human exposure to surface water, sediments, and groundwater in the MAA until background concentrations of COCs were achieved. Protection of the environment would also be provided when background concentrations of risk drivers in MAA surface water were achieved. It is anticipated that a recovery period that may be on the order of one to several decades would be required to achieve background concentrations in MAA media. Restrictions on groundwater use within the MA would be needed for the foreseeable future.

5.3.7.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Currently in the three drainages south of the MA, maximum

concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations.

Under Alternative 4e, loads of COCs and risk drivers discharged to Blue Creek and the mine drainages would be further reduced through source containment and expanded groundwater collection and treatment. As a result, concentrations of these contaminants may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. The time frame for Blue Creek would be shorter than for the mine drainages.

The concentrations of some constituents in the WTP effluent, including uranium, manganese, and sulfate, currently exceed Tribal water quality standards and background. Treatability studies would be needed to determine what modifications would need to be made to the WTP to further reduce concentrations of these constituents to meet water quality ARARs. As discussed in Section 5.3.1.4, EPA is continuing to work with the Tribe to determine discharge requirements for sulfate. A preliminary evaluation of potential costs to treat sulfate to a concentration of 250 mg/L or lower is presented in Section 5.5.

Groundwater. Under Alternative 4e, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 260 acres). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations.

Alternative 4e includes source containment and expanded groundwater collection and treatment, which should prevent further migration of the plume and improve groundwater quality compared to current conditions. Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades.

Within the WMA, Alternative 4e includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and

adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 4e, areas with concentrations of COCs that exceed ARARs would be covered (within the MA) or excavated (haul roads and adjacent areas), which would result in compliance with potential ARARs for surface materials. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 4e, areas with concentrations of COCs that exceed ARARs would be excavated and disposed of in the existing open pits, which would result in compliance with potential ARARs for sediment.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Protective covers installed within the MA under Alternative 4e would reduce radon flux to levels that comply with the 40 CFR 61 standard.

Waste Management. Disposal of ore, protore, and waste rock in the open pits would meet the substantive requirements of RCRA Subtitle D. Since the ore, protore, and waste rock are Bevill-exempt materials, RCRA Subtitle C would not be an ARAR. Because these materials are byproducts of mining operations that are naturally occurring and not concentrated or chemically altered by human processes, Section 34-1.12 (Disposal of Hazardous Substances) of the Tribal HSCA would not apply.

If onsite disposal of treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. Alternative 4e would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

5.3.7.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 4e to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and water treatment sludge at the conclusion of remedial activities under Alternative 4e are evaluated in this section.

Surface Water and Groundwater. Under Alternative 4e, uranium loads in the Eastern Drainage would be reduced to an estimated 21 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, would be reduced under Alternative 4e. Risks would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit exposure, risks could be reduced to protective levels.

Under Alternative 4e, risks from exposure to surface water in the open pits would be eliminated.

Sediment. The evaluation of residual risks due to sediment is the same as under Alternative 4d.

Surface Materials. The evaluation of residual risks due to surface materials is the same as under Alternative 4d.

Air. The evaluation of residual risks due to radon in air is the same as under Alternative 4d.

Water Treatment Sludge. Risks from potential exposure to water treatment sludge (estimated average of 220 tons per year) would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 4e.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage residual risks under Alternative 4e, including pit drains (drainage blankets and horizontal boreholes), water collection and treatment, sediment excavation, and other controls, are evaluated in this section.

Pit Drains (Drainage Blankets). Drainage blankets would be constructed of competent, non-reactive material. Monzonite, which decomposes over time, would not be suitable for

construction of drainage blankets. Precipitation processes (e.g., precipitation of calcium carbonate or iron oxides), deposition of fine-grained soil, or biofouling could cause a loss of permeability and effectiveness of the drainage blanket. Periodic maintenance (e.g., injection of acidic chemicals) may be required to rehabilitate drainage blankets affected by biofouling or precipitates. The effects of fine-grained soil deposition could be limited by using a filter fabric between the drainage blanket and the overlying mine waste. Monitoring of water levels within the pits and discharge from the drains would be required to assess whether the passive drains are functioning as designed. Long-term maintenance of the pit drainage systems would be required and, if maintenance is unsuccessful, poor quality groundwater could accumulate in the pits, similar to the existing backfilled pits.

Pit Drains (Horizontal Boreholes). The capacity of the boreholes could be reduced by clogging as a result of biofouling, precipitation processes, or piping of fine soil into the borehole. The effects of soil piping could be limited by using a graded filter around the drain inlet. Periodic maintenance (e.g., injection of acidic chemicals) may be required to rehabilitate drains affected by biofouling or precipitates. Monitoring of water levels within the pits and discharge from the drains would be required to assess whether the passive drains are functioning as designed. Should a condition develop where the drains are not functioning adequately, and where rehabilitation is not feasible, a potential contingency measure would be to extract water in the pits using vertical wells.

Water Collection and Treatment. The adequacy and reliability of water collection and treatment are the same as described under Alternative 2b, except the potential for releases of untreated water would be a consideration because Pit 3 would no longer provide temporary storage capacity.

Other Controls. The adequacy and reliability of controls including protective covers, stormwater management systems, and institutional controls would be the same as described under Alternative 3c.

Summary. Under Alternative 4e, residual risks to tribal members and tribal resources would be reduced from current conditions. However, residual risks would continue to exist in surface materials, surface water, and groundwater. Risks from these media would be managed through use of access and institutional controls. These controls include restrictions on the open pit highwalls, WTP (3 acres), cover areas (310 acres), and sludge disposal site, if any (2 acres). Reliance on access and institutional controls and information programs lacks certainty at this site due to regulatory context (e.g., limited Tribal mechanisms, allottee rights, and federal jurisdiction).

In addition, Alternative 4e necessitates long-term indefinite operation of the water treatment system which will require perpetual funding for and performance of long-term operations and

maintenance. Water treatment requirements and the potential for releases of contaminated water would be reduced to an estimated average of 38,000,000 gallons per year.

5.3.7.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 4e includes treatment of contaminated seep water, highwall runoff water, and pit groundwater using an active, ex-situ treatment process, which is described in Section 5.3.1.4. Under Alternative 4e, the toxicity of an estimated average of 38,000,000 gallons per year of contaminated water would be reduced using active treatment. The water treatment sludge would be dewatered and solidified to reduce the potential for leaching of COCs. The process would produce an estimated 220 tons of dewatered and solidified sludge per year. The active treatment process is considered irreversible; i.e., no significant remobilization of COCs would be expected assuming the sludge is disposed of such that it is not subject to leaching.

5.3.7.6 Short-Term Effectiveness

Protection of Community and Workers. Under Alternative 4e, considerations for protection of the community and workers would be generally the same as those described under Alternative 3c.

Environmental Impacts. Potential short-term environmental impacts under Alternative 4e are generally similar to those described under Alternatives 3c and 4d. An additional consideration is the potential for releases of contaminated water during construction after backfilling of Pit 3 has started. Although alternative water storage and temporary increases in water treatment capacity would be necessary during the dewatering and backfilling of the pits, releases could occur if the volumes of contaminated water exceed the capacity of these controls.

Time Until RAOs are Achieved. RAOs for surface materials and air and MA surface water and sediment would be achieved when cover construction is complete. An estimated 3 to 4 years would be required for development of cover materials sources, construction of passive drains, partial backfilling of the open pits, and cover construction. MAA sediment response actions could be completed and sediment RAOs achieved within one year of completion of cover construction. To the extent access and use restrictions are effective, RAOs for protection of human health from exposure to MA groundwater and MAA surface water, groundwater, surface water, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to MAA surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved at the completion of remedy construction. A recovery period that may be on the order of one to several decades may be needed to achieve these RAOs.

Under Alternative 4e, the recovery period for ecological receptors of one to several decades has an ongoing short-term impact to Tribal resources.

5.3.7.7 Implementability

Technical Feasibility. An implementability consideration for Alternative 4e would be the ability to contain and treat contaminated water after Pit 3 was backfilled, including the ability to conduct water treatment year-round. Converting to year-round treatment would potentially require modifications to the pumpback system and WTP to prevent freezing. If ventilation of the WTP is reduced to maintain warmer conditions and prevent freezing, worker exposures to indoor radon would need to be evaluated. Facilities for over-winter storage of sludge would need to be provided, or roads would need to be improved or maintained to enable sludge hauling during the winter.

Construction of passive drains is considered to be technically implementable using current technology for directional drilling. An additional consideration is the ability to segregate adequate quantities (estimated 190,000 cy) of suitable non-reactive waste rock to construct passive drains. This material is intermixed with unsuitable waste rock, and segregation of suitable material could slow earthwork operations. If suitable material cannot be segregated from onsite waste rock, then drain rock could be imported from an offsite vendor at a higher cost.

Monitoring could effectively measure the success of Alternative 4e in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 4e would preclude additional remedial action, if it were needed in the future. Once a cover is in place, however, additional remediation that involves moving covered materials would be more costly.

Administrative Feasibility. A potential administrative feasibility consideration is the ability to meet the applicable or relevant and appropriate requirements of the Tribal HSCA for a new disposal facility for sludge, if onsite disposal is used.

Compliance with the ESA may require consultation, a biological assessment, or other actions which could delay initiation of cleanup.

Offsite actions may require permits. Surface mining permits from Tribal, state, or local agencies may be required to excavate borrow materials. Potential difficulties in obtaining permits may delay implementation or increase costs.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require extensive coordination with the BIA, as well as coordination and consultation with the Tribe.

Availability of Services and Materials. Considerations related to the availability of suitable cover materials are described under Alternative 3c. Considerations related to the availability of offsite disposal capacity for an estimated average of 5,800 cubic feet of water treatment sludge per year are described under Alternative 2b. There are adequate sources of labor, equipment, and reagents to conduct active water treatment and dewater and solidify the sludge. Specialized contractors and equipment would be required for construction of horizontal boreholes, which could impact construction scheduling and costs.

5.3.7.8 Cost

A range of costs has been estimated for Alternative 4e. The low end of the range ("base" cost) was estimated assuming onsite sludge disposal. The high end of the range ("base plus incremental" cost) was estimated assuming offsite sludge disposal at the Richland facility and increased thicknesses of protective covers. The estimated costs are summarized as follows.

- Estimated capital cost = $80,000,000 (base) to $86,000,000 (base + incremental)
- Estimated average annual O&M cost = $1,300,000 (base) to $2,600,000 (base + incremental)
- Total estimated present worth cost (7%, 30 years) = $97,000,000 (base) to $116,000,000 (base + incremental)
- Total estimated present worth cost (3.1%, 140 years) = $123,000,000 (base) to $167,000,000 (base + incremental)

Alternative 4e also includes periodic costs for replacement of the WTP. Table 5-19 presents a breakdown of estimated costs under Alternative 4e.

A capital cost uncertainty under Alternative 4e is the cost of providing non-reactive rock for construction of the drainage blankets. If this material cannot be readily segregated from onsite waste rock, or if it must be imported from an offsite source, the cost of drainage blanket construction would increase.

Uncertainties related to the cost of sludge disposal are the same as described under Alternative 3c. In addition, O&M costs for water treatment would increase if poor quality groundwater accumulates in Pit 3 and Pit 4, which would be partially backfilled under Alternative 4e.

A preliminary evaluation of costs for modifications to the WTP that may be needed to meet surface water RAOs is presented in Section 5.5.

5.3.8 Alternative 5a (Complete Pit Backfill with Passive Drains and Ex-Situ Water Treatment)

5.3.8.1 Description

The primary elements of Alternative 5a include:

- Excavation and consolidation of all waste material, including ore and protore, waste rock, haul roads soil, and contaminated sediment, within Pit 3 and Pit 4, except waste rock within the existing backfilled pits
- Construction of passive drains in the bases of Pit 3 and Pit 4 to maintain the groundwater level below the waste materials, which is intended to reduce impacts to groundwater in the pits
- Construction of passive drains from the existing backfilled pits to Pit 3, and placement of a cover over the existing backfilled pits
- Construction of a stormwater management system
- Replacement of the WTP at a new location; temporary treatment units would be used during remedy construction to supplement the treatment capacity
- Excavation of contaminated soil in the haul roads and adjacent impacted areas; the soil would be consolidated with the mine waste and placed in Pit 3 or Pit 4
- Excavation of contaminated MAA sediments; the sediments would be consolidated with the mine waste and placed in Pit 3 or Pit 4
- Institutional controls, including use restrictions and information programs, and access controls
- Long-term monitoring and 5-year reviews

An overview summary of the elements of Alternative 5a is presented in Table 5-3. A summary of institutional controls included under Alternative 5a is presented in Table 5-4.

Alternative 5a includes excavation and consolidation of all mining waste material on the site within the existing open pits, except material within the existing backfilled pits. Mining waste that could not be contained within Pit 3 and Pit 4 would be mounded over the existing backfilled pits area to enhance surface water runoff. To further reduce radon flux, high activity concentration materials such as ore and protore would be buried in the pits beneath tens of feet of waste rock. A thin cover would be placed over the filled pit areas, including the existing backfilled pits, to limit surface water percolation and radon flux. A layer of suitable soil would be placed over areas cleared of mine waste, as needed, to enhance revegetation of these areas. A

conceptual cover plan for Alternative 5a is shown in Figure 5-14. To increase the capacities of the pits, the following measures would be implemented.

- Materials placed in the pits would be compacted to increase their density.
- The fill prism would extend above the pre-mining surface. The side slopes of the fill prism would be no steeper than 3H:1V.
- The footprint of the fill prism would include the entire drainage area of the pits, as defined by the subwaste topography.

An evaluation of the capacity of Pit 3, Pit 4, and the area over the backfilled pits is presented in Appendix E. This evaluation suggests that the capacity is adequate to contain all waste material, assuming the material is compacted to a density of 80 to 90 percent of the average standard Proctor density.

Passive drains, as described under Alternative 4e, would be constructed to maintain the groundwater levels in Pit 3 and Pit 4 below the waste material and limit the interaction of groundwater with reactive materials. Approximately 1.2 million cy of non-reactive, free-draining rock would be required to construct 5-foot-thick drainage blankets in Pit 3 and Pit 4. For FS analysis, it is assumed the drainage blankets would be constructed using calc-silicate waste rock.

The pit drainage system would also include passive drains from both Pit 2 and the Boyd Pit to Pit 3 to convey contaminated water from the backfilled pits to the Pit 3 drainage system. The drains would be constructed by drilling from the ground surface above the Boyd Pit and Pit 2, through the low points in the pits, and into Pit 3 using directional drilling techniques. A liner would be pulled through and grouted in place to limit leakage out of the drill hole. The liner would extend from the low points in the pit to Pit 3. The liners would be connected to a well casing that extends from the ground surface to the low point of the existing backfilled pit. The well casing would be screened at the elevation of the bottom of the pit.

Some potential would exist for the passive drains to fail to function as designed. If the drains should fail, the groundwater level could rise into the waste materials, and poor quality groundwater could collect within the pits. The potential for poor quality groundwater could be mitigated by placing non-reactive waste rock in the zone immediately above the basal drainage blanket, to the extent these materials can be identified and segregated. In addition, groundwater extraction wells could be installed should the passive drains fail.

After implementation of Alternative 5a, areas containing mining waste would be limited to the existing open pits and the backfilled pits, an area of approximately 97 acres. To protect the integrity of the covers and limit exposure, residential use, excavation, and motorized vehicle use would be prohibited within these areas.

Excavation of the South Spoils and East Dump would eliminate the seeps at the MA boundary. All mining waste would be removed from the area that drains to the Western Drainage, which should restore streamflow in the Western Drainage within the MA. The Western Drainage currently is the source of the majority of seep water collected from the site.

Water treatment would continue, as needed. The extent of treatment that would be needed is uncertain at this time. For FS analysis, it is assumed water collected in the pit drainage system would be treated, because this water may contact reactive rock in the pit walls or in the mine waste that would be contained in the pits. This water would be collected where it discharges from the drains and treated using active ex-situ treatment. In areas of the drainages where mine waste is excavated to bedrock, the potential would exist for runoff water to contain COCs at concentrations exceeding background. The potential would be greatest in areas where bedrock consists of schists of the Togo formation (primarily the eastern half of the site). For FS analysis, it is assumed for FS analysis that surface water in the drainages would not require treatment. To the extent surface water in the drainages after remedy construction contains COCs at levels that exceed background COC levels, use restrictions would be implemented.

Because the existing water treatment plant is located on waste rock that would be placed in Pit 3, the plant would be dismantled. Since the plant is nearing the end of its life cycle, it is assumed the plant would be replaced rather than reassembled. The new plant would be capable of year-round operation, and its capacity would be increased to 1,000 gpm to meet treatment requirements during remedy construction. There are two primary reasons for these upgrades. First, the additional capacity would enable rapid dewatering of the open pits and extend the construction season. Second, use of the open pits for untreated water storage would be limited after backfilling of the pits had begun, and additional treatment capacity would be needed to prevent untreated discharge of potentially large runoff and seep flows during the winter and spring.

For FS analysis, an estimate of future treatment requirements was made, as described in Appendix C. The estimated average future water treatment rate is approximately 13 million gallons per year, and the estimated average future sludge generation is 80 tons per year after dewatering (2,100 cubic feet per year).

If onsite disposal is used, it is assumed the disposal facility would be constructed with a 100-year capacity. Based on an estimated volumetric sludge generation rate of 2,100 cubic feet per year, the required disposal facility capacity would be 210,000 cubic feet (8,000 cy). For an assumed average waste thickness of 20 feet, the disposal facility footprint would be less than 1 acre.

Alternative 5a presents logistical problems for remedy staging because mine waste would continue to be exposed to water during constriction, producing contaminated runoff and seep flows after Pit 3 is rendered unusable for water storage. Backfilling of the pits would require a minimum of two construction seasons. As a result, at least one winter season would pass with

uncontained ore, protore, and waste rock and no significant water storage capacity available. The amount of contaminated water that might be produced during a winter season is potentially large. During the winter of 1996-1997, the volume of water in Pit 3 increased from approximately 265 million gallons at the end of WTP operations in November 1996 to approximately 370 million gals at the start of WTP operations in April 1997, an increase of 105 million gallons. The pit gained water at an average rate of approximately 550 gpm, and transient rates would have been higher. The majority of this change in storage represented contaminated water that would be unsuitable for discharge without treatment.

It is anticipated that water could be treated or contained during construction using a combination of measures, including year-round operation of the WTP, increased WTP capacity, in-pit water storage, and water storage in the PCP. As described above, the WTP capacity would be increased to 1,000 gpm for treatment of contaminated water during remedy construction. In-pit storage capacity would be provided by backfilling the pits in cells. Cells not actively receiving backfill would be used for temporary water storage. Once a cell has been filled to a predetermined elevation, it would be converted to a water-storage cell, and the previous water-storage cells would be backfilled. Cells used for temporary water storage would be lined with a synthetic liner to limit leakage.

A potential staging of construction activities under Alternative 5a is as follows:

- The treatment plant would be dismantled, waste rock and ore removed from the plant location and stockpiled onsite, and a new plant capable of year-round operation constructed at the current plant location (or a suitable alternate location).
- Starting when the high seep discharge period associated with spring runoff ends, Pits 3 and 4 and the PCP would be dewatered. After dewatering is complete, drains would be constructed in Pits 3 and 4 and the backfilled pits.
- Pit 3 and Pit 4 would be backfilled.
- Cleanup actions for drainage sediments would be implemented.

It is estimated that implementation of Alternative 5a would require approximately six to seven years. Approximately two construction seasons would be required to reconstruct the WTP, dewater the open pits, and construct passive drains. The time to backfill the pits would depend on the intensity of construction activities. For FS analysis, it is assumed two years would be required to completely backfill the pits. Stockpiling of cover material would be conducted concurrently with consolidation. Following completion of pit backfilling, the estimated time to complete cover construction is one year. The estimated time to complete cleanup actions for drainage sediments is one year.

After completion of construction, collected seep water would continue to be routed directly to the WTP, which would have been upgraded to permit year-round operation. If offsite sludge

disposal is used, temporary onsite sludge storage or year-round sludge hauling would be required.

Alternative 5a includes the same response actions for contaminated haul road soils and drainage sediments as those described under Alternative 4d.

5.3.8.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. Ore, protore, and waste rock would be contained within the existing open pits and backfilled under a protective cover. This containment system would eliminate the direct ingestion pathway, reduce radon flux to the NESHAPs and UMTRCA standard (20 pCi/m^2/s), and reduce external radiation to protective levels. Land use limitations and periodic inspections and maintenance would be required to ensure the integrity of the cover. The area of land use restrictions would be approximately 97 acres.

Backfilling of the existing open pits would involve excavating and hauling approximately 16,300,000 cy of ore, protore, and waste rock. Short-term considerations related to backfilling the pits include increased worker risks due to the large volume of earthwork involved and the ability to effectively contain contaminated site water once Pit 3 became unavailable for water storage.

Construction of the protective cover and revegetation of disturbed areas would involve importing 600,000 to 800,000 cy of cover materials. Mining and hauling of cover materials potentially would increase traffic hazards and short-term environmental impacts at borrow sites; however, these effects would be reduced compared to other alternatives due to the smaller volume of cover materials involved.

Surface Water and Sediment in Open Pits. Under Alternative 5a, the surface water and sediment exposure pathways in the open pits would be eliminated. However, if contaminated water flows exceed the capacity of the treatment system, it would be necessary to provide a contaminated water storage pond. Such a pond would be a potential source of exposure to contaminated surface water and sediment, similar to the existing pit lakes.

Groundwater Within the MA. Under Alternative 5a, use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. After a period of recovery, which may be on the order of one to several decades, it may be possible to discontinue the use restrictions in areas of the MA from which waste materials have been removed. The use restrictions would be needed for the foreseeable future within the areas where waste materials are consolidated (approximately 97 acres).

Groundwater in the existing backfilled pits would be drained into backfilled Pit 3, where it would be collected and treated. Assuming the drainage systems function as designed, these measures would result in containment and treatment of all water that comes in contact with mine waste, which could limit transport of contaminants from MA groundwater to surface water to very low levels. Some potential would exist for the drainage systems in backfilled Pit 3 and Pit 4 and the existing backfilled pits to fail. Should this occur, poor quality groundwater could accumulate in these pits.

Groundwater and Surface Water in Mine Drainages and Blue Creek. Alternative 5a would improve groundwater and surface water quality compared to existing conditions by reducing contact of water and oxygen with mine waste. The mine waste would be contained in Pits 3 and 4 and the existing backfilled pits, which would be passively drained to keep the water level below the mine waste. Seep collection and operation of the existing treatment system would be continued, as needed. The results of these actions are expected to include:

- Ore, protore, and waste rock would be completely removed down to the level of the pre-mining topography from the Western Drainage, thereby restoring unimpeded flow in the drainage within the MA and eliminating the existing Western Drainage seeps. An estimated average of 34,000,000 gallons per year of runoff water within the MA from areas currently covered by mine waste would be conveyed to the drainages as clean water.
- Ore, protore, and waste rock would be completely removed down to the level of the pre-mining topography from the Central Drainage, except for the existing backfilled pits, which would be hydraulically isolated through passive drainage into Pit 3. Flow would be restored in the Central Drainage, including run-off from the graded cover over the existing backfilled pits area, and the existing Central Drainage seeps at the toe of the South Spoils and near the PCP would be eliminated.
- Surface water quality in the mine drainages would improve because discharge of groundwater to the drainages would be reduced from an estimated average of 17,000,000 gallons per year to an estimated average of 12,000,000 gallons per year, and the quality of this groundwater probably would improve.
- An estimated 13,000,000 gallons per year of water would be collected in the existing open pits and backfilled pits passive drainage systems. This water would be treated using the existing active treatment system.

As a result of these source control and water treatment actions, the estimated average uranium load in the Eastern Drainage under Alternative 5a would be reduced to approximately 25 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1 (Appendix F). This limited analysis suggests that the average uranium concentration in Blue Creek may be reduced to the background concentration over time.

Surface water and groundwater quality in the mine drainages may also approach background conditions over time. It is anticipated a longer recovery period would be needed than for Blue Creek. The recovery period may be on the order of one to several decades. To the extent surface water and groundwater contain COCs at concentrations that exceed protective levels after implementation of Alternative 5a, use restrictions and information programs would be included to limit exposures.

Sediment in Mine Drainages and Blue Creek. Sediment quality in MAA drainages generally would continue to improve over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas. This natural recovery process would be supplemented by excavation of contaminated sediments under Alternative 5a. These actions would limit exposure of humans and animals to concentrations of COCs and risk drivers that exceed background levels. Some short-term sediment quality impacts would likely occur as a result of these excavation activities and remedy construction activities within the MA. The potential for such impacts is greater under Alternative 5a than other alternatives, except Alternative 5c, due to the much larger volume of earthwork involved. These impacts could be limited through use of sediment control BMPs.

Haul Roads Soil. Under Alternative 5a, exposure to contaminated soil within and adjacent to the haul roads would be reduced to protective levels by excavating the contaminated material and disposing of it together with the ore and protore in Pit 3.

Plant and Animal Tissue. Under Alternative 5a, excavation and consolidation of contaminated surface material beneath a soil cover would be used to reduce uptake of COCs by plants and animals within the MA. These measures should reduce concentrations of COCs in terrestrial plants in the MA to background levels, which would allow these plants to be safely consumed by livestock or other animals. In addition, the cover should reduce uptake of COCs in animal tissue through consumption of these plants to background levels, which would allow humans to safely consume the animal tissue.

Removal, containment and treatment actions implemented under Alternative 5a would improve surface water and sediment quality within the MAA, which would reduce uptake of COCs by plants and animals. Information programs would be implemented to reduce human ingestion of contaminated plant and animal tissue from the MAA, including Blue Creek, until background concentrations of COCs in surface water and sediment are achieved.

Summary. In summary, Alternative 5a would provide protection of human health and the environment. Institutional controls would be used to reduce human exposure to surface water and groundwater in the MAA and areas of the MA where mine waste has been removed until background concentrations of COCs were achieved. Protection of the environment would also be provided when background concentrations of risk drivers in surface water were achieved. It is anticipated that a recovery period that may be on the order of one to several decades would be required to achieve background concentrations in surface water and groundwater in the MAA and areas of the MA where mine waste has been removed. Restrictions on groundwater use in areas where mine waste is consolidated would be needed for the foreseeable future.

5.3.8.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations.

Under Alternative 5a, loads of COCs and risk drivers discharged to Blue Creek and the mine drainages would be further reduced through containment of all mine waste within the existing open pits and the existing backfilled pits. As a result, concentrations of these contaminants may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. The time frame for Blue Creek would be shorter than for the mine drainages.

The concentrations of some constituents in the WTP effluent, including uranium, manganese, and sulfate, currently exceed Tribal water quality standards and background. Treatability studies

would be needed to determine what modifications would need to be made to the WTP to further reduce concentrations of these constituents to meet water quality ARARs. As discussed in Section 5.3.1.4, EPA is continuing to work with the Tribe to determine discharge requirements for sulfate. A preliminary evaluation of potential costs to treat sulfate to a concentration of 250 mg/L or lower is presented in Section 5.5.

Groundwater. Under Alternative 5a, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 97 acres). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background. At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations.

Alternative 5a includes containment of all mine waste within the existing open pits and the existing backfilled pits and treatment of water that collects within these pits, which should prevent further migration of the plume and improve groundwater quality compared to current conditions. Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades.

Within the WMA, Alternative 5a includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 5a, areas with concentrations of COCs that exceed ARARs would be excavated and disposed of beneath a protective cover, which would result in compliance with potential ARARs for surface materials. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese,

radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 5a, areas with concentrations of COCs that exceed ARARs would be excavated and disposed of in the existing open pits, which would result in compliance with potential ARARs for sediment.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Protective covers installed within the MA under Alternative 5a would reduce radon flux to levels that comply with the 40 CFR 61 standard.

Waste Management. Disposal of ore, protore, and waste rock in the open pits would meet the substantive requirements of RCRA Subtitle D. Since the ore, protore, and waste rock are Bevill-exempt materials, RCRA Subtitle C would not be an ARAR. Because these materials are byproducts of mining operations that are naturally occurring and not concentrated or chemically altered by human processes, Section 34-1.12 (Disposal of Hazardous Substances) of the Tribal HSCA would not apply.

If onsite disposal of treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. Alternative 5a would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. The recovery period may be somewhat shorter under Alternative 5a than under Alternatives 3c, 3d, 4d, and 4e because sources of contaminated groundwater may be more effectively contained. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

5.3.8.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 5a to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and water treatment sludge at the conclusion of remedial activities under Alternative 5a are evaluated in this section.

Surface Water and Groundwater. Under Alternative 5a, uranium loads in the Eastern Drainage would be reduced to an estimated 25 pounds per year, compared to an estimated 100 pounds per

year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, would be reduced under Alternative 5a. Risks would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit use, risks could be reduced to protective levels.

Under Alternative 5a, risks from exposure to surface water in the open pits would be eliminated. Some potential would exist for formation of poor quality water within the backfilled pits, should be passive drains fail. In this case, extraction wells would be used to maintain the groundwater level in the pits below the base of the waste materials.

Sediment. Risks from exposure to sediment in the open pits would be eliminated. Risks from exposure to COCs in sediment in the drainages and Blue Creek would decline from current levels as a result of isolation of ore, protore, and waste rock in the MA from surface water runoff and contaminated sediment excavation. Some risk would remain in areas where sediments are not excavated due to potential adverse ecological impacts; however, risks likely would be reduced to protective levels over time.

Surface Materials. Risks from exposure to external radiation and COCs in surface materials would be reduced to acceptable levels, as long as the integrity of the cover system is maintained.

Air. The areawide average radon flux in the MA would be reduced from approximately 50 $pCi/m^2/s$ to 20 $pCi/m^2/s$ or less in areas where ore, protore, and waste rock would be consolidated and to background levels (approximately 3.2 $pCi/m^2/s$) in areas where these materials would be removed. The flux level of to 20 $pCi/m^2/s$ was adopted in NESHAPs and UMTRCA for radon source areas (e.g., the MA) to provide acceptable risk levels for residential use in adjacent areas (e.g., the MAA). Land use restrictions that limit used of the covered areas to transient foot traffic would be used to reduce risks from radon inhalation within the MA following attainment of the 20 $pCi/m^2/s$ standard.

Water Treatment Sludge. Risks from potential exposure to water treatment sludge (estimated average of 80 tons per year) would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 5a.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage residual risks under Alternative 5a, including complete pit backfill and other controls, are evaluated in this section.

Complete Open Pit Backfill. Backfilled open pits would incorporate a drainage system, as described under Alternative 4e, to reduce the potential for accumulation of poor quality groundwater in the pits. To the extent non-reactive waste rock could be identified and segregated, it may be possible to further mitigate this potential by placing the non-reactive rock in the zone above the drainage blanket.

Covers over the backfilled pits would be placed at slopes no steeper than 3H:1V. Periodic maintenance would be required to repair areas damaged by erosion. If necessary, the capacities of Pit 3 and Pit 4 could be increased by placing backfill at slopes steeper than 3H:1V; however, steeper side slopes would be more susceptible to erosion and may need increased maintenance.

Other Controls. The adequacy and reliability of controls including protective covers, stormwater management systems, water treatment, and institutional controls would be the same as described under Alternative 3c. Under Alternative 5c, the area of use restrictions needed to protect the integrity of the cover systems would be reduced to approximately 97 acres. The adequacy and reliability of sediment excavation would be the same as described under Alternative 4d. The adequacy and reliability of pit drains would be generally the same as described under Alternative 4e. Alternative 5a also includes horizontal passive drains from the backfilled pits to Pit 3. Horizontal drains from the backfilled pits would be daylighted on the surface of the pits to facilitate maintenance.

Summary. Under Alternative 5a, residual risks to tribal members and tribal resources would be reduced from current conditions. However, residual risks would continue to exist in surface materials, surface water, and groundwater. Risks from these media would be managed through use of access and institutional controls. These controls include restrictions on the WTP (3 acres), water storage pond (5 acres) covered area (97 acres) and sludge disposal site, if any (2 acres). Reliance on access and institutional controls and information programs lacks certainty at this site due to unique regulatory structure (e.g., limited Tribal mechanisms, allottee rights and federal jurisdiction).

In addition, Alternative 5a necessitates long-term indefinite operation of the water treatment system which will require perpetual funding for and performance of long-term operations and maintenance. The estimated average future water treatment rate is approximately 13 million gallons per year

5.3.8.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 5a includes treatment of contaminated water collected in the pit drainage systems using an active ex-situ treatment process, which is described in Section 5.3.1.4. Under Alternative 5a, the toxicity of an estimated average of 13,000,000 gallons per year of contaminated water would be reduced using active treatment. The water treatment sludge would be dewatered and solidified to reduce the potential for leaching of COCs. The process would produce an estimated 80 tons of dewatered and solidified sludge per year. The active treatment process is considered irreversible; i.e., no significant remobilization of COCs would be expected assuming the sludge is disposed of such that it is not subject to leaching.

5.3.8.6 Short-Term Effectiveness

Protection of Community and Workers. Risks to the community from importing cover materials would be similar to those described under Alternative 3c, but the magnitude may be reduced due to the smaller volume of cover material (estimated 600,000 to 800,000 cy) required. However, if drainage blanket materials (approximately 1,200,000 cy) must be imported from an offsite source, risks to the community would increase. Risks to workers during earthwork operations would be greater under Alternative 5a than under other alternatives due to the much larger volume of material involved. Potential risks to workers would result from exposure to radiation during treatment of an estimated annual average of 13,000,000 gallons of water. These risks would be managed by using practices required by the plant's health and safety plan. If offsite sludge disposal is used, potential risks to the community would result from hauling an estimated annual average of 80 tons of sludge. These risks would be managed by employing standard hazardous materials hauling practices.

Environmental Impacts. Potential environmental impacts include the generation of sediment-laden runoff during earthwork operations, which include excavation of 16,300,000 cy of ore, protore, and waste rock. The impact of this runoff could be limited using sediment control BMPs. Potential short-term impacts would result from sediment removal actions in riparian areas within the drainages. Engineering controls such as sediment fencing, sediment traps, revegetation, and biostabilization measures would be used to limit these impacts.

An additional consideration is the potential for releases of contaminated water during construction after backfilling of Pit 3 has started. Although alternative water storage and temporary increases in water treatment capacity would be necessary during the dewatering and backfilling of the pits, releases could occur if the volumes of contaminated water exceed the capacity of these controls (Section 5.3.8.7).

If new offsite borrow sources are developed for cover material, the potential for short-term environmental impacts at these sites would also exist. These impacts could include increased uncontaminated sediment loads from runoff and erosion, destruction of existing vegetation and

habitat, and degradation of topsoil quality. Standard engineering controls such as sediment fencing and revegetation would reduce these impacts.

Time Until RAOs are Achieved. RAOs for surface materials and air and MA surface water and sediment would be achieved when cover construction is complete. An estimated five to six years would be required until cover construction is complete. MAA sediment response actions could be completed and sediment RAOs achieved within one year of completion of cover construction. To the extent access and use restrictions are effective, RAOs for protection of human health from exposure to MA groundwater and MAA surface water, groundwater, surface water, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to MAA surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved at the completion of remedy construction. A recovery period that may be on the order of one to several decades may be needed to achieve these RAOs.

Under Alternative 5a, the recovery period for ecological receptors of one to several decades has an ongoing short-term impact to Tribal resources.

5.3.8.7 Implementability

Technical Feasibility. Technical feasibility considerations related to the ability to construct and maintain passive drains and conduct water treatment year-round would be similar to those described under Alternative 4e. Under Alternative 5a, a larger quantity (estimated 1,200,000 cy) of suitable, non-reactive waste rock would be needed to construct passive drains. This material is intermixed with unsuitable waste rock, and segregation of suitable material could slow earthwork operations. If suitable material cannot be segregated from onsite waste rock, then drain rock could be imported from an offsite vendor at a higher cost.

As described in Section 5.3.8.1, Alternative 5a presents logistical problems for remedy staging because of the need to contain or treat contaminated water once Pit 3 becomes unavailable for temporary untreated water storage. It is anticipated that water could be treated or contained during construction using a combination of measures, including year-round operation of the WTP, increased WTP capacity, in-pit water storage, and water storage in the PCP. However, these measures could impact construction scheduling and increase construction costs. It would be important to have all necessary equipment, materials, and funding available so that backfilling and cover construction could be completed without extended delays.

Monitoring could effectively measure the success of Alternative 5a in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 5a would preclude additional remedial action, if it were needed in the future.

Administrative Feasibility. A potential administrative feasibility consideration is the ability to meet the applicable or relevant and appropriate requirements of the Tribal HSCA for a new disposal facility for sludge.

Compliance with the ESA may require consultation, a biological assessment, or other actions which could delay initiation of cleanup.

Offsite actions may require permits. Surface mining permits from Tribal, state, or local agencies may be required to excavate borrow materials. Potential difficulties in obtaining permits may delay implementation or increase costs.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require extensive coordination with the BIA, in addition to coordination and consultation with the Tribe.

Availability of Services and Materials. Considerations related to the availability of suitable cover materials are described under Alternative 3c. Considerations related to the availability of offsite sludge disposal capacity are described under Alternative 2b.

These considerations would be reduced under Alternative 5a because the required cover material volumes and estimated sludge volumes would be lower. The estimated volume of soil required for cover construction is 600,000 to 800,000 cy. Cover materials would not be needed until complete backfilling of the pits was completed. As a result, identification and development of cover materials sources may not impact construction scheduling.

Specialized contractors and equipment would be required for construction of passive drains, which could impact construction scheduling and costs. There are adequate sources of labor, equipment, and reagents to conduct active water treatment and dewater and solidify the sludge.

5.3.8.8 Cost

A range of costs has been estimated for Alternative 5a. The low end of the range ("base" cost) was estimated assuming onsite sludge disposal. The high end of the range ("base plus incremental" cost) was estimated assuming offsite sludge disposal at the Richland facility and increased thicknesses of protective covers. The estimated costs are summarized as follows.

- Estimated capital cost = $117,000,000 (base) to $118,000,000 (base + incremental)
- Estimated average annual O&M cost = $820,000 (base) to $1,300,000 (base + incremental)
- Total estimated present worth cost (7%, 30 years) = $127,000,000 (base) to $133,000,000 (base + incremental)

- Total estimated present worth cost (3.1%, 140 years) = $144,000,000 (base) to $159,000,000 (base + incremental)

Alternative 5a also includes periodic costs for replacement of the WTP. Table 5-20 presents a breakdown of estimated costs under Alternative 5a.

Consolidation of waste materials in the open pits accounts for approximately one half of the estimated capital cost of Alternative 5a. A capital cost uncertainty under Alternative 5a is the cost of providing non-reactive rock for construction of the drainage blankets. If this material cannot be readily segregated from onsite waste rock, or if it must be imported from an offsite source, the cost of drainage blanket construction would increase.

An O&M cost uncertainty under Alternative 5a is related to the need to treat surface water that would drain to the Western and Central Drainages. The estimated cost for Alternative 5a assumes this water would be released without treatment. If the water is not suitable for release without treatment, O&M costs would be higher. In addition, O&M costs for water treatment would increase if poor quality groundwater accumulates in Pit 3 and Pit 4, which would be backfilled under Alternative 5a.

A preliminary evaluation of costs for modifications to the WTP that may be needed to meet surface water RAOs is presented in Section 5.5.

5.3.9 Alternative 5c (Complete Pit Backfill including Excavation of Backfilled Pits and Water Treatment)

5.3.9.1 Description

The description of Alternative 5c is based on material provided by the Tribe (AESE, Inc. 2003) and the Midnite Mine Natural Resources Trustees Council (2004). Alternative 5c includes institutional controls, excavation and consolidation of mine waste within Pit 3 and Pit 4, and water treatment, as described under Alternative 5a. The primary difference between Alternative 5c and Alternative 5a is that all waste rock in the existing backfilled pits would be excavated and placed in Pits 3 and 4 under Alternative 5c. The primary elements of Alternative 5a that are incorporated in Alternative 5c are:

- Excavation and consolidation of all waste material, including ore and protore, waste rock, haul roads soil, and contaminated sediment, within Pit 3 and Pit 4
- Construction of a stormwater management system
- Replacement of the WTP at a new location; temporary treatment units would also be used during remedy construction to supplement the treatment capacity

- Excavation of contaminated soil in the haul roads and adjacent impacted areas; the soil would be consolidated with the mine waste and placed in Pit 3 or Pit 4
- Excavation of contaminated MAA sediments; the sediments would be consolidated with the mine waste and placed in Pit 3 or Pit 4
- Institutional controls, including use restrictions and information programs, and access controls
- Long-term monitoring and 5-year reviews

Alternative 5c differs from Alternative 5a in the following elements:

- Waste rock in the existing backfilled pits would be excavated and placed in Pits 3 and 4; intact rock also would be excavated from the backfilled pits to the extent needed to provide drainage of water to the Central Drainage.
- An FML would be placed in Pit 3 and 4 prior to placement of waste materials in the pits. This basal FML would cover the base of the pits and extend part way up the pit walls. The purposes of the basal FML would be to further reduce the potential for contact between water and reactive rock and further protect the drainage blanket from deposition of contaminants and fine soil that would be contained in water percolating through the waste materials (particularly during construction).
- Waste materials placed in Pits 3 and 4 would be contained using a cap consisting of an FML and 2.7 feet of soil.
- Backfilled Pits 3 and 4 would be drained using extraction wells instead of passive gravity drains.
- In general, bedrock exposed by excavation activities would not be revegetated.
- The WTP effluent would be conveyed to the Spokane Arm of Lake Roosevelt for discharge.

An overview summary of the elements of Alternative 5c is presented in Table 5-3. A summary of institutional controls included under Alternative 5c is presented in Table 5-4.

The materials designated for consolidation in Pit 3 and Pit 4 include all material excavated during mining (including the backfilled pits; approximately 38 million tons [SMI 1996]), less the ore hauled to the mill (2.9 million tons [SMI 1996]), a total of approximately 35 million tons. In addition, an allowance of one million tons is included for overexcavation of intermixed waste rock and native soil. The total weight of this material (approximately 36 million tons) exceeds the weight of material removed from Pit 3 and Pit 4 combined (approximately 33 million tons). In addition, it would not be feasible to place the material back into the pits at a density as great as that of the undisturbed, pre-mining rock. Thus, the combined capacity of Pit 3 and Pit 4 is potentially a limiting factor under Alternative 5c.

To increase the capacities of the pits, the following measures would be implemented.

- Materials placed in the pits would be compacted to increase their density.
- The fill prism would extend above the pre-mining surface. The side slopes of the fill prism would be no steeper than 3H:1V.
- The footprint of the fill prism would include the entire drainage area of the pits, as defined by the subwaste topography.

A cross section of Pit 3 after backfilling is shown in Figure 5-15, and the footprints of the fill prisms in Pit 3 and Pit 4 are shown in Figure 5-16.

An evaluation of the capacity of Pit 3 and Pit 4 is presented in Appendix E. This evaluation suggests that the waste material would need to be compacted to a density of approximately 100 percent of the average standard Proctor density, assuming the pit drainage blankets can be constructed using onsite waste rock. The evaluation further suggests that the waste material would need to be compacted to an average standard Proctor density of greater than 100 percent to contain all waste material if the pit drainage blankets cannot be constructed using onsite waste rock.

Some options exist to further increase the capacities of the pits or reduce the volume of material that needs to be contained within the pits. One option would be to construct the fill prisms using steeper side slopes to increase their capacities. In this case, the slopes would be more susceptible to erosion and would require more long-term maintenance. A second option would be to segregate materials that would not need to be contained in the pits because they contain low levels of radionuclides and do not leach COCs. The specific locations of such materials have not been identified at this time. A third option would be to increase the capacities of the pits by blasting and hauling out materials in the pit walls that would not need to be contained within the pits (i.e., materials that contain low levels of radionuclides and do not leach COCs).

Drainage wells would be constructed to maintain the groundwater levels in Pit 3 and Pit 4 below the waste material and limit the interaction of groundwater and reactive materials. Drainage wells would be placed both above and below the basal FML. To protect the integrity of the basal FML, the drainage wells would be constructed as backfilling operations proceeded. Two wells above the liner and two wells below the liner would be installed to provide redundancy in case a well were to become unproductive.

Approximately 1.2 million cy of non-reactive, free-draining rock would be required to construct 5-foot-thick drainage blankets in Pit 3 and Pit 4. For FS analysis, it is assumed the drainage blankets would be constructed using calc-silicate waste rock. To the extent feasible, a layer of non-reactive waste rock would be placed immediately above the basal liner and below ore and protore to further reduce the potential for contact of water and reactive materials. High activity

concentration materials such as ore and protore would be buried under tens of feet of waste rock in the pits to minimize radon and radiation fluxes from these materials.

Assuming all waste material could be placed within Pit 3 and Pit 4, areas containing mining waste after implementation of Alternative 5c would be limited to the footprint areas of the caps over Pit 3 and Pit 4. To protect the integrity of the caps and limit exposure, residential use, excavation, and motorized vehicle use would be prohibited within the cap areas. A conceptual capping plan for Alternative 5c is shown in Figure 5-16. The footprint of Pit 3 cap is 49 acres, and the footprint of Pit 4 cap is 31 acres. For a cap including 2.7 feet of soil, approximately 400,000 cy of soil would be needed.

All mining waste would be removed from the areas that drain to the Western Drainage and Central Drainage, which would restore streamflow in these drainages within the MA. Excavation of the South Spoils and East Dump would eliminate the seeps at the MA boundary. Areas from which mining waste would be removed generally would not be revegetated, which would result in higher peak flows in these drainages compared to pre-mining conditions.

Water treatment would continue, as needed. The extent of treatment that would be needed is uncertain at this time. Reactive rock is present within the pit walls, including the existing backfilled pits. Surface water and groundwater may interact with this reactive rock and become contaminated. Groundwater that seeps into the pits from bedrock also may be contaminated as a result of its interaction with unmined ore or other reactive rock that has been exposed to oxygen. Therefore, it is assumed for FS analysis that water that collects in the Pit 3 and Pit 4 drainage systems and runoff and seepage within the existing backfilled pits would contain elevated levels of COCs and would need treatment. The potential also would exist for runoff water to contain COCs at levels greater than background in other areas of the drainages where ore, protore, and waste rock are excavated to bedrock. The potential would be greatest in areas where bedrock consists of schists of the Togo formation (primarily the eastern half of the site). Relatively little of the drainage area of the Western Drainage consists of the Togo formation. For FS analysis, it is assumed that surface water in the Western Drainage would not need treatment. To the extent surface water in the drainages after remedy construction contains COCs at levels that exceed background COC levels, use restrictions would be implemented.

For FS analysis, an estimate of future treatment requirements was made, as described in Appendix C, using the assumptions that runoff and seepage from the existing backfilled pits area would need to be collected and treated, and runoff from the Western Drainage would not need to be treated. The estimated average future water treatment rate is approximately 10 million gallons per year, and the estimated average future sludge generation is 40 tons per year after dewatering (approximately 1,000 cubic feet per year).

If onsite disposal is used, it is assumed the disposal facility would be constructed with a 100-year capacity. Based on an estimated volumetric sludge generation rate of 1,000 cubic feet per year,

the required disposal facility capacity would be approximately 100,000 cubic feet (3,700 cy). For an assumed average waste thickness of 20 feet, the disposal facility footprint would be less than 1 acre.

Effluent from the WTP would be conveyed through a buried pipe to discharge in the Spokane Arm of Lake Roosevelt. The outlet would be located south of the reservation boundary. The reservation boundary is defined by the southern bank of the Spokane River as it existed before the bank was submerged by Lake Roosevelt.

A potential staging of construction activities under Alternative 5c includes a site preparation phase and a construction phase (Midnite Uranium Mine Natural Resources Trustees Council 2004).

Site Preparation Phase

1a. Construct new water treatment plant and associated conveyances. The new WTP would probably be located near the Ford-Wellpinit Road and would be capable of year-round operation.

1b. Retrofit the existing WTP to increase capacity and provide the ability to operate year-round, if necessary. Install a discharge line from both WTPs to the Spokane Arm of Lake Roosevelt.

2a. Dewater Pit 3 following the spring recharge period.

2b. Discontinue pumping from Pit 4 until the water level in the pit reaches the elevation of the alluvium/bedrock contact. Water in Pit 4 would be used as a source of relatively clean wash-down and dust-control water.

3. Excavate material from the southern perimeter of Pit 3, if necessary, to provide additional pit capacity.

Construction Phase

1. Construct Pit 3 drain blanket, drainage system, and basal flexible membrane liner.

2. Begin filling Pit 3 with non-acid generating rock from the backfilled pits area and, if appropriate, the high-lime pile (Stockpile 8). Continue filling with ore, protore, and waste rock to final elevation.

3. Construct and revegetate Pit 3 cap.

4. Backfill Pit 4 using same procedure as described for Pit 3.

5. Dismantle pre-existing WTP.

Cleanup actions for MAA sediments would be implemented after completion of cap construction. It is estimated that implementation of Alternative 5c would require approximately six to eight years.

Alternative 5c presents logistical problems for remedy staging because contaminated water would continue to be produced after Pit 3 becomes unavailable for temporary water storage, as described under Alternative 5a. Because material in the backfilled pits would be excavated, the construction time for Alternative 5c would be longer than for Alternative 5a, which would increase the amount of contaminated water that would need to be contained and treated during construction. The approach to containing and treating contaminated water during construction under Alternative 5c would be similar to the approach described under Alternative 5a.

Alternative 5c includes the same response actions for contaminated haul road soils and drainage sediments as those described under Alternative 4d. These materials would be disposed of in Pit 4.

The Tribe has suggested possible modifications to Alternative 5c, including:

- Grouting of fractures in the highwalls of Pit 3 and the existing backfilled pits, which would be exposed by excavation of mine waste, to maintain reactive rock in a saturated condition and limit generation of ARD
- Addition of a mixture of molasses, ethanol, and other organic compounds to the pits during construction to precipitate metals
- Installation of a drip irrigation system beneath the FML cap for additions of the above mixture, as needed, after construction is complete to precipitate metals
- Excavation of calc-silicate rock from the southeast highwall of Pit 3, which has excess acid-neutralization capacity, for use in the drainage blankets in Pits 3 and 4
- Construction of passive drains in Pits 3 and 4; the drains would include leaky bulkheads to limit movement of oxygen into the drainage blankets
- Discharge of Pits 3 and 4 groundwater that would drain through the leaky bulkheads directly to the ground surface
- Use of the excavated backfilled pits area as an engineered disposal area, including a drainage blanket, a basal FML liner, and a low-permeability cover, if additional mine waste disposal capacity is needed

- Placement of soil over excavated areas to promote revegetation, if an inexpensive, local source of soil is available

The effectiveness, implementability, and cost of these possible modifications to Alternative 5c have not been evaluated at this time. The modifications could be evaluated during remedial design.

5.3.9.2 Overall Protection of Human Health and the Environment

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Similarly, based on the results of the EcoRA, the concentrations of one or more risk drivers in surface water, sediment, and surface material must be reduced to approximately background to protect ecological receptors.

MA Surface Materials, including External Radiation and Airborne Radon. Ore, protore, and waste rock would be contained within the existing open pits and backfilled under a protective cap. This containment system would eliminate the direct ingestion pathway, reduce radon flux to less than the NESHAPs and UMTRCA standard (20 $pCi/m^2/s$), and reduce external radiation to protective levels. Land use limitations and periodic inspections and maintenance would be required to ensure the integrity of the cap; however, the area of land use restrictions (approximately 80 acres) would be reduced compared to other alternatives.

Backfilling of the existing open pits would involve excavating and hauling approximately 19,000,000 cy of ore, protore, waste rock, and overexcavation soil. Short-term considerations related to backfilling the pits include increased worker risks due to the large volume of earthwork involved and the ability to effectively contain contaminated site water once Pit 3 became unavailable for water storage.

Construction of the protective cap would involve importing approximately 400,000 cy of capping materials. Mining and hauling of capping materials potentially would increase traffic hazards and short-term environmental impacts at borrow sites. To the extent onsite materials could be used in cap construction, the potential for these impacts would be reduced.

Surface Water and Sediment in Open Pits. Under Alternative 5c, the surface water and sediment exposure pathways in the open pits would be eliminated. However, if contaminated water flows exceed the capacity of the treatment system, it would be necessary to provide a contaminated water storage pond. This could occur if runoff from the existing backfilled pits area needs to be treated. Such a pond would be a potential source of exposure to contaminated surface water and sediment, similar to the existing pit lakes.

Groundwater Within the MA. Under Alternative 5c, use restrictions are included to reduce potential future human exposures to contaminated groundwater within the MA. After a period of recovery, which may be on the order of one to several decades, it may be possible to discontinue the use restrictions in areas of the MA from which waste materials have been removed. The use restrictions would be needed for the foreseeable future within the areas where waste materials are consolidated (approximately 80 acres).

Assuming the drainage systems in Pit 3 and Pit 4 function as designed, these measures would result in containment and treatment of all water that comes in contact with mine waste, which could limit transport of contaminants from MA groundwater to surface water to very low levels. Some potential would exist for the drainage systems to fail. Should this occur, poor quality groundwater could accumulate in the pits.

Groundwater and Surface Water in Mine Drainages and Blue Creek. Alternative 5c would improve groundwater and surface water quality compared to existing conditions by reducing contact of water and oxygen with mine waste. This would be accomplished primarily by containing these materials above the water level in the existing open pits, which would be drained. Seep collection and operation of the existing treatment system would be continued, as needed. The results of these actions are expected to include:

- Ore, protore, and waste rock would be completely removed to pre-mining topography from the Western and Central Drainages, thereby restoring unimpeded flow to these drainages (with the possible exception of the existing backfilled pits area) within the MA and eliminating the existing seeps at the toe of the South Spoils and near the PCP. An estimated average of 55,000,000 gallons per year of runoff water within the MA from areas currently covered by mine waste would be conveyed to the drainages as clean water.
- Surface water quality in the drainages would be improved because discharge of groundwater to the drainages would be reduced from an estimated average of 17,000,000 gallons per year to an estimated average of 12,000,000 gallons per year, and the quality of this groundwater probably would be improved.
- An estimated average of 10,000,000 gallons per year of water would be collected in the existing open pits and backfilled pits areas. This water would be treated using the existing active treatment process.

As a result of these source control and water treatment actions, the estimated average uranium load in the Eastern Drainage under Alternative 5c would be reduced to approximately 29 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1 (Appendix F). This limited analysis suggests that the average uranium concentration in Blue Creek may be reduced to the background concentration over time.

Surface water and groundwater quality in the mine drainages also may approach background conditions over time. It is anticipated a longer recovery period would be needed than for Blue Creek. The recovery period may be on the order of one to several decades. To the extent surface water and groundwater contain COCs at concentrations that exceed protective levels after implementation of Alternative 5c, use restrictions and information programs would be included to limit exposures.

Sediment in Mine Drainages and Blue Creek. Sediment quality in MAA drainages generally would continue to improve over time as sediment released during mining is flushed out of the system and replaced by sediment derived from unaffected areas. This natural recovery process would be supplemented by excavation of contaminated sediments under Alternative 5c. These actions would limit exposure of humans and animals to concentrations of COCs and risk drivers that exceed background levels. Some short-term sediment quality impacts would likely occur as a result of these excavation activities and remedy construction activities within the MA. The potential for such impacts is greater under Alternative 5c than other alternatives due to the larger volume of earthwork involved. These impacts could be limited through use of sediment control BMPs.

Haul Roads Soil. Under Alternative 5c, exposure to contaminated soil within and adjacent to the haul roads would be reduced to protective levels by excavating the contaminated material and disposing of it in Pit 3.

Plant and Animal Tissue. Under Alternative 5c, the evaluation of plant and animal tissue is the same as under Alternative 5a.

Summary. In summary, Alternative 5c would provide protection of human health and the environment. Institutional controls would be used to reduce human exposure to surface water and groundwater in the MAA and areas of the MA where mine waste has been removed until background concentrations of COCs were achieved. Protection of the environment would be provided when background concentrations of risk drivers in surface water were achieved. It is anticipated that a recovery period of one to several decades would be required to achieve background concentrations in surface water and groundwater in the MAA and areas of the MA where mine waste has been removed. Restrictions on groundwater use in areas where mine waste is consolidated would be needed for the foreseeable future.

5.3.9.3 Compliance with ARARs

In this section, compliance with potential surface water, groundwater, sediment, and surface material ARARs is evaluated using the procedure described in Section 5.2.2. Compliance with potential air and waste management ARARs is also discussed in this section.

Surface Water. A comparison of concentrations of COCs in surface water measured during the RI to potential ARARs for protection of human health is presented in Table 5-7. As shown, with the exception of uranium, the ARAR for the five human-health based surface water COCs is background. Currently at one or more locations in Blue Creek and in the three drainages south of the MA, maximum concentrations of uranium exceed the Tribal water quality standard for protection of human health for consumption of water and organisms, and maximum concentrations of manganese exceed Tribal water quality standards for ceremonial and spiritual uses.

A comparison of concentrations of risk drivers in surface water measured during the RI to potential ARARs for protection of aquatic organisms is presented in Table 5-8. Currently in Blue Creek, no risk drivers exceed potential ARARs (for aluminum, the ARAR is background) for protection of aquatic life. Currently in the three drainages south of the MA, maximum concentrations of dissolved cadmium, copper, nickel, silver, and zinc exceed Tribal water quality standards or EPA national recommended water quality criteria for protection of aquatic life at one or more locations.

Under Alternative 5c, loads of COCs and risk drivers discharged to Blue Creek and the mine drainages would be further reduced through containment of all mine waste within the existing open pits. As a result, concentrations of these contaminants may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. The time frame for Blue Creek would be shorter than for the mine drainages.

Under Alternative 5c, the effluent from the WTP would be piped to the Spokane Arm of Lake Roosevelt south of the reservation boundary. At this location, State of Washington water quality standards would be potential ARARs. Concentrations of contaminants monitored in the WTP effluent typically have been lower than the State of Washington water quality standards. Should temporary exceedances occur, the state water quality standards allow for a mixing zone if the discharger has applied all known, available, and reasonable methods of prevention, control, and treatment.

Groundwater. Under Alternative 5c, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 80 acres). Concentrations of COCs in groundwater outside of the WMA that were measured during the RI are compared to potential ARARs for protection of human health in Table 5-9. As shown, the ARAR for the four groundwater COCs is background.

At the monitoring well location adjacent to Blue Creek, no COCs have been detected at concentrations that exceed potential groundwater ARARs. Maximum concentrations of manganese and uranium exceed potential ARARs at one or more MAA monitoring well locations.

Alternative 5c includes containment of all mine waste within the existing open pits and treatment of water that collects within these pits, which should prevent further migration of the plume and improve groundwater quality compared to current conditions. Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades.

Within the WMA, Alternative 5c includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Surface Materials. A comparison of concentrations of COCs in surface materials measured during the RI to potential ARARs for protection of human health is presented in Table 5-10. As shown, the ARAR for the three soil COCs is background. Within the MA and within and adjacent to the haul roads, maximum concentrations of lead, radium, and uranium exceed potential ARARs at one or more locations. Under Alternative 5c, areas with concentrations of COCs that exceed ARARs would be excavated and disposed of beneath a protective cover, which would result in compliance with potential ARARs for surface materials. There are no potential surface materials ARARs for protection of ecological receptors.

Sediment. A comparison of concentrations of COCs in sediment measured during the RI to potential ARARs for protection of human health is presented in Table 5-11. As shown, with the exception of manganese, the ARAR for the five human-health based sediment COCs is background. Within Blue Creek, maximum concentrations of manganese exceed potential sediment ARARs for the protection of human health at one or more locations. In the three drainages south of the MA and in the open pits, maximum concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs for the protection of human health at one or more locations. Under Alternative 5c, areas with concentrations of COCs that exceed ARARs would be excavated and disposed of in the existing open pits, which would result in compliance with potential ARARs for sediment.

Within Blue Creek, the three drainages south of the MA, and the open pits, the risk driver chromium was not detected at concentrations that exceed potential sediment ARARs for the protection of sediment-dwelling organisms. No potential ARARs exist for the risk drivers manganese and uranium.

Air. Protective covers installed within the MA under Alternative 5c would reduce radon flux to levels that comply with the 40 CFR 61 standard.

Waste Management. Disposal of ore, protore, and waste rock in the open pits would meet the substantive requirements of RCRA Subtitle D. Since the ore, protore, and waste rock are Bevill-exempt materials, RCRA Subtitle C would not be an ARAR. Because these materials are

byproducts of mining operations that are naturally occurring and not concentrated or chemically altered by human processes, Section 34-1.12 (Disposal of Hazardous Substances) of the Tribal HSCA would not apply.

If onsite disposal of treatment sludge is used, an onsite disposal area would be sited and constructed that complies with the substantive requirements of RCRA Subtitle C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

Summary. Alternative 5c would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. The recovery period may be somewhat shorter under Alternative 5c than under Alternatives 3c, 3d, 4d, and 4e because sources of contaminated groundwater may be more effectively contained.

5.3.9.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk and the adequacy and reliability of controls used under Alternative 5c to manage these risks are evaluated in this section.

Magnitude of Residual Risk. The magnitude of risks remaining in surface water, groundwater, sediment, surface materials, air, and water treatment sludge at the conclusion of remedial activities under Alternative 5c are evaluated in this section.

Surface Water and Groundwater. Under Alternative 5c, uranium loads in the Eastern Drainage would be reduced to an estimated 29 pounds per year, compared to an estimated 100 pounds per year under current conditions and more than two orders of magnitude less than the estimated uranium load of 10,000 pounds per year under Alternative 1. Thus, risks from exposure to uranium in surface water, a risk driver for ingestion of surface water, would be reduced under Alternative 5c. Risks would be further reduced through institutional controls that would restrict use of impacted water. To the extent these institutional controls successfully limit use, risks would be reduced to protective levels.

Under Alternative 5c, risks from exposure to surface water in the open pits would be eliminated. Some potential would exist for formation of poor quality water within the backfilled pits should the extraction wells become unproductive. Alternative 5c includes redundant wells to reduce the likelihood of failure of the pit dewatering system.

Sediment. The evaluation of residual risks due to sediment is the same as under Alternative 5a.

Surface Materials. Risks from exposure to external radiation and COCs in surface materials would be reduced to acceptable levels, as long as the integrity of the cap is maintained.

Air. The evaluation of residual risks due to radon in air is the same as under Alternative 5a.

Water Treatment Sludge. Risks from potential exposure to water treatment sludge (estimated average of 40 tons per year) would be limited by restricting public access to temporary sludge storage areas, implementing worker health and safety programs, and solidifying the sludge and disposing of it in an onsite or offsite repository designed to be protective of human health and the environment.

Long-term monitoring and maintenance would be needed to ensure the effectiveness of Alternative 5c.

Adequacy and Reliability of Controls. The adequacy and reliability of controls used to manage residual risks under Alternative 5c, including dewatering wells, FML covers, Lake Roosevelt discharge pipeline, and other controls, are evaluated in this section.

Dewatering wells. Dewatering wells are susceptible to losses in capacity due to siltation or deposition of precipitates on the well screens. Periodic maintenance may be needed to restore well capacity, and redundant wells could be installed to provide additional capacity. Installation of new wells after backfilling is complete may compromise the basal FML liner.

FML cover. Covers that include FMLs would further limit water percolation and radon flux compared to soil covers that do not include FMLs. The FML would mitigate the effects of potential damage resulting from erosion or other factors (see discussion of protective covers under Alternative 3c). However, over the long term, the FML would be subject to deterioration, and reducing percolation and radon flux would primarily be accomplished by the soil cover.

Lake Roosevelt discharge pipeline. The pipeline would be susceptible to damage from erosion and slope movement. It would run through uncontrolled areas, and could be damaged by excavation activities. Periodic inspections and maintenance would be needed to identify and repair any damage.

Other Controls. The adequacy and reliability of controls including protective covers, stormwater management systems, water treatment, extraction wells, and institutional controls would be the same as described under Alternative 3c. Under Alternative 5c, the area of use restrictions needed to protect the integrity of the cover systems would be reduced to approximately 80 acres. The adequacy and reliability of sediment excavation would be the same as described under Alternative 4d. The adequacy and reliability of complete pit backfill would be the same as described under Alternative 5a.

Summary. Under Alternative 5c, residual risks to tribal members and tribal resources would be reduced from current conditions. However, residual risks would continue to exist in surface materials, surface water, and groundwater. Risks from these media would be managed through

use of access and institutional controls. These controls include restrictions on the WTP (3 acres), water storage pond (5 acres) cover area (80 acres) and sludge disposal site, if any (1 acre). Reliance on access and institutional controls and information programs lacks certainty at this site due to unique regulatory structure (e.g., limited Tribal mechanisms, allottee rights, and federal jurisdiction).

In addition, Alternative 5c necessitates long-term indefinite operation of the water treatment system, which will require perpetual funding for and performance of long-term operations and maintenance. The estimated average future water treatment rate is approximately 10 million gallons per year.

5.3.9.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 5c includes treatment of contaminated water collected in the pit drainage systems using an active ex-situ treatment process, which is described in Section 5.3.1.4. Under Alternative 5c, the toxicity of an estimated average of 10,000,000 gallons per year of contaminated water would be reduced using active treatment. The water treatment sludge would be dewatered and solidified to reduce the potential for leaching of COCs. The process would produce an estimated 40 tons of dewatered and solidified sludge per year. The active treatment process is considered irreversible; i.e., no significant remobilization of COCs would be expected assuming the sludge is disposed of such that it is not subject to leaching.

5.3.9.6 Short-Term Effectiveness

Protection of Community and Workers. Risks to the community from importing cover materials would be similar to those described under Alternative 3c, but the magnitude would be reduced due to the smaller volume of material (estimated 400,000 cy) required. However, if drainage blanket materials (approximately 1,200,000 cy) must be imported from an offsite source, risks to the community would increase. Risks to workers during earthwork operations would be greater under Alternative 5c than under other alternatives due to the large volume of material involved. Potential risks to workers would result from exposure to radiation during treatment of an estimated annual average of 10,000,000 gallons of water. These risks would be managed by using practices required by the plant's health and safety plan. If offsite sludge disposal is used, potential risks to the community would result from hauling an estimated annual average of 40 tons of sludge. These risks would be managed by employing standard hazardous materials hauling practices.

Environmental Impacts. Potential environmental impacts include the generation of sediment-laden runoff during earthwork operations, which include excavation of approximately 19,000,000 cy of ore, protore, waste rock, and overexcavation soil. The impact of this runoff could be limited using sediment control BMPs. Potential short-term impacts would result from sediment removal actions in riparian areas within the drainages. Engineering controls such as

sediment fencing, sediment traps, revegetation, and installation of bioengineering measures would be used to limit these impacts.

An additional consideration is the potential for releases of contaminated water during construction after backfilling of Pit 3 has started. Although alternative water storage and temporary increases in water treatment capacity would be necessary during the dewatering and backfilling of the pits, releases could occur if the volumes of contaminated water exceed the capacity of these controls. (See Section 5.3.9.7.)

If new offsite borrow sources are developed for cover material, the potential for short-term environmental impacts at these sites would also exist. These impacts could include increased uncontaminated sediment loads from runoff and erosion, destruction of existing vegetation and habitat, and degradation of topsoil quality. Standard engineering controls such as sediment fencing and revegetation would reduce these impacts.

Time Until RAOs are Achieved. RAOs for surface materials and air and MA surface water and sediment would be achieved when cover construction is complete. An estimated five to six years would be required until cover construction is complete. MAA sediment response actions could be completed and sediment RAOs achieved within one year of completion of cover construction. To the extent access and use restrictions are effective, RAOs for protection of human health from exposure to MA groundwater and MAA surface water, groundwater, surface water, and sediment would be achieved within less than one year. However, RAOs for protection of ecological receptors from exposure to MAA surface water and RAOs for protection of surface water quality from discharges of COCs in groundwater would not be completely achieved at the completion of remedy construction. A recovery period that may be on the order of one to several decades may be needed to achieve these RAOs.

Under Alternative 5c, the recovery period for ecological receptors of one to several decades has an ongoing short-term impact to Tribal resources.

5.3.9.7 Implementability

Technical Feasibility. Technical feasibility considerations related to the ability to construct and maintain passive drains and conduct water treatment year-round would be similar to those described under Alternative 4e.

As described in Section 5.3.9.1, Alternative 5c presents logistical problems for remedy staging because of the need to contain or treat contaminated water once Pit 3 becomes unavailable for temporary untreated water storage. It is anticipated that water could be treated or contained during construction using a combination of measures, including year-round operation of the WTP, increased WTP capacity, in-pit water storage, and water storage in the PCP. However, these measures could impact construction scheduling and increase construction costs. It would

be important to have all necessary equipment, materials, and funding available so that backfilling and cover construction could be completed without extended delays.

An additional consideration is the ability to segregate an estimated 1,200,000 cy of suitable non-reactive waste rock to construct passive drains. This material is intermixed with unsuitable waste rock, and segregation of suitable material could slow earthwork operations. If adequate quantities of suitable material cannot be segregated from onsite waste rock, then drain rock could be imported from an offsite vendor at a higher cost.

Monitoring could effectively measure the success of Alternative 5c in achieving the RAOs, and the results of the monitoring and periodic inspections would give notice if maintenance or additional action were needed. No component of Alternative 5c would preclude additional remedial action, if it were needed in the future.

Administrative Feasibility. A potential administrative feasibility consideration is the ability to meet the applicable or relevant and appropriate requirements of the Tribal HSCA for a new disposal facility for sludge.

Compliance with the ESA may require consultation, a biological assessment, or other actions which could delay initiation of cleanup.

Offsite actions may require permits. Surface mining permits from Tribal, state, or local agencies may be required to excavate borrow materials. Potential difficulties in obtaining permits may delay implementation or increase costs.

An additional potential administrative feasibility consideration is whether the Tribe and BIA have the ability to implement effective institutional controls on Tribal and allotment lands. Such actions would require extensive coordination with the BIA, as well as coordination and consultation with the Tribe.

Availability of Services and Materials. Considerations related to the availability of suitable cover materials are described under Alternative 3c. Considerations related to the availability of offsite sludge disposal capacity are described under Alternative 2b. These considerations would be reduced under Alternative 5c because the required cover material volumes and estimated sludge volumes would be lower. The estimated volume of soil required for cover construction is 400,000 cy. Cover materials would not be needed until complete backfilling of the pits was completed. As a result, identification and development of cover materials sources may not impact construction scheduling.

There are adequate sources of labor, equipment, and reagents to conduct active water treatment and dewater and solidify the sludge.

5.3.9.8 Cost

A range of costs has been estimated for Alternative 5c. The low end of the range ("base" cost) was estimated assuming onsite sludge disposal and shorter haul distances for cover materials. The high end of the range ("base plus incremental" cost) was estimated assuming offsite sludge disposal at the Richland facility and longer haul distances for cover materials. The estimated costs are summarized as follows.

- Estimated capital cost = $124,000,000 (base) to $125,000,000 (base + incremental)
- Estimated average annual O&M cost = $650,000 (base) to $900,000 (base + incremental)
- Total estimated present worth cost (7%, 30 years) = $132,000,000 (base) to $136,000,000 (base + incremental)
- Total estimated present worth cost (3.1%, 140 years) = $146,000,000 (base) to $154,000,000 (base + incremental)

Alternative 5c also includes periodic costs for replacement of the WTP. Table 5-21 presents a breakdown of estimated costs under Alternative 5c.

Consolidation of waste materials in the open pits accounts for approximately one half of the estimated capital cost of Alternative 5c. The estimated cost assumes the cover would be constructed using offsite soil. To the extent onsite soil could be used in the cover, the estimated cost would be reduced. A capital cost uncertainty under Alternative 5c is the cost of providing non-reactive rock for construction of the drainage blankets. If this material cannot be readily segregated from onsite waste rock, or if it must be imported from an offsite source, the cost of drainage blanket construction would increase.

An O&M cost uncertainty under Alternative 5c is related to the need to treat surface water that would be discharged in the Western and Central Drainages. The estimated cost for Alternative 5c assumes surface water from the existing backfilled pits area of the Central Drainage would be treated and surface water from the Western Drainage would not be treated. In addition, O&M costs for water treatment would increase if poor quality groundwater accumulates in Pit 3 and Pit 4, which would be backfilled under Alternative 5c.

A preliminary evaluation of costs for modifications to the WTP that may be needed to meet surface water RAOs is presented in Section 5.5.

5.4 COMPARATIVE ANALYSIS

This section evaluates the cleanup alternatives in relation to one another for each of the seven CERCLA threshold and primary balancing criteria. State and community acceptance will be addressed in the ROD following public comment on the RI/FS reports and the Proposed Plan. The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each alternative within each criterion. The comparative analysis is intended to identify the key tradeoffs that decision-makers must balance in the remedy selection process. It is not the purpose of this section to identify a preferred alternative.

In the following subsections, the alternatives are discussed in numerical order for the threshold criteria. Each alternative is evaluated for whether it satisfies the threshold criteria. For each balancing criterion, the alternative that best satisfies each criterion is presented and analyzed first, with subsequent alternatives discussed in descending rank order. Table 5-22 presents a summary of the comparative analysis.

5.4.1 Overall Protection of Human Health and the Environment

Each of the alternatives, except Alternative 1 (No Action), would potentially provide adequate protection of human health and the environment, although the alternatives rely to varying degrees on institutional controls for protection of human health and on natural recovery periods of varying duration. During natural recovery, some environmental receptors would not be protected. For all alternatives, access and use restrictions would be necessary to ensure the effectiveness of containment, although the area affected differs among the alternatives. The O&M requirements for collection and treatment of contaminated water also vary among the alternatives.

Based on the results of the HHRA, the concentrations of the one or more COCs in surface water, groundwater, sediment, and surface materials must be reduced to approximately background, or the pathway eliminated, to reduce the incremental risk due to the release to acceptable levels under an unlimited use scenario. Therefore, use restrictions would be required in areas where background levels would not be achieved. The long-term effectiveness of use restrictions would depend on continued enforcement by the Tribal authorities or other entities. In particular, restrictions on surface water use may be difficult to enforce.

5.4.1.1 Alternative 1 (No Action)

Alternative 1 would not provide protection of human health and the environment. No engineered controls or institutional controls would be used to limit exposure. Alternative 1 would be less protective than existing conditions. Estimated total risks and hazards for all unlimited use

exposure scenarios would exceed acceptable levels by more than two orders of magnitude.[16] The extent and magnitude of groundwater and surface water contamination would increase.

5.4.1.2 Alternative 2b (Institutional Controls and Ex-Situ Water Treatment)

Alternative 2b would provide protection of human health, but may not be protective of the environment. Protection of human health would rely on extensive use of institutional controls, including restricting access to the entire MA, restricting use of groundwater throughout the MA and drainages, restricting use of the haul roads, and limiting traditional or residential uses of surface water in the MA, mine drainages, and Blue Creek. Risks to ecological receptors, however, generally would not be mitigated by the institutional controls. Because Alternative 2b does not include further mine waste containment, water collection and treatment volumes and associated sludge volumes would be greater than under other alternatives. As the reactive materials continued to weather over time, leaching of COCs from mine waste would slow down and eventually become insignificant; however, this process could take centuries.

5.4.1.3 Alternatives 3c (Above Grade Containment and Ex-Situ Water Treatment) and 3d (Above Grade Containment and In-Situ Water Treatment)

Alternatives 3c and 3d would provide protection of human health and the environment. Containment of ore, protore, and waste rock would be used to reduce residual risks from exposure to surface materials, radon, and external radiation to acceptable levels. Land use restrictions would be required for covered areas (243 acres) to ensure the integrity of the containment systems.

Containment and active (Alternative 3c) or in-situ (Alternative 3d) water treatment would be used to reduce concentrations of COCs in surface water and groundwater. However, a recovery period that may be on the order of one to several decades would be needed until concentrations of COCs in MAA groundwater and surface water are reduced to background levels. Until background levels are reached, use restrictions would be required to provide protection of human health. It is not anticipated that COC concentrations in surface water and groundwater within areas of waste containment in the MA would be reached within the foreseeable future. As a result, use restrictions and access restrictions (open pits) would be required to provide protection of human health in these areas. The open pits would continue to be used by wildlife that could not be excluded by fencing under both Alternative 3c and Alternative 3d, although the water quality would be improved significantly by treatment under Alternative 3d.

For Alternative 3d, treatability studies would be required to demonstrate the long-term effectiveness of in-situ treatment. The need to conduct treatability studies and obtain reactive media could extend the implementation time under Alternative 3d. Potential community impacts

[16] Unlimited use exposure scenarios evaluated include residential and non-residential use scenarios for both the MA and the MAA.

would be associated with transporting an estimated 1,000,000 to 2,000,000 cy of material to the site for cover construction under Alternatives 3c and 3d.

5.4.1.4 Alternatives 4d (Partial Pit Backfill and In-Situ Treatment) and 4e (Partial Pit Backfill with Passive Drainage and Ex-Situ Water Treatment)

Alternatives 4d and 4e would provide protection of human health and the environment. Similar to Alternatives 3c and 3d, containment of mine waste would reduce risks from exposure to surface materials, radon, and external radiation to acceptable levels. Alternatives 4d and 4e would provide an additional increment of protectiveness compared to Alternatives 3c and 3d by eliminating the surface water exposure pathway in the open pits. The potential for formation of poor quality groundwater within the pits would be mitigated by creating geochemical conditions that would result in low COC mobility under Alternative 4d and by hydraulically isolating wastes materials using passive drains under Alternative 4e.

Containment and in-situ (Alternative 4d) or ex-situ (Alternative 4e) water treatment would be used to reduce concentrations of COCs in surface water and groundwater. As under Alternatives 3c and 3d, a recovery period would be needed to reach background COC concentrations in MAA surface water and groundwater. Until background concentrations are reached, use restrictions would be required to provide protection of human health. The duration of the recovery period under Alternatives 4d and 4e is anticipated to be similar to the recovery period under Alternatives 3c and 3d.

Implementation times for Alternatives 4d and 4e would be somewhat longer than for Alternative 3c and 3d because of the time needed to partially backfill the pits. Treatability studies would be required to demonstrate the long-term effectiveness of in-situ treatment included under Alternative 4d. The need to conduct treatability studies and obtain suitable organic amendments could extend the implementation time under Alternative 4d. Potential community impacts associated with transporting material to the site for cover construction would be similar to those that would occur under Alternatives 3c and 3d.

5.4.1.5 Alternatives 5a (Complete Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) and 5c (Excavation of Backfilled Pits, Complete Pit Backfill, and Ex-Situ Water Treatment)

Alternative 5a and Alternative 5c would provide protection of human health and the environment. Containment of mine waste in the existing open pits would be used to reduce risks from exposure to surface materials, radon, and external radiation to acceptable levels. The extent of land use restrictions (97 acres under Alternative 5a and 80 acres under Alternative 5c) required to ensure the integrity of the containment systems would be reduced compared to the other alternatives.

Removal of mine waste in the drainages in the MA, containment of these materials in the drained pits, and water treatment would reduce migration of COCs to surface water and groundwater. The resulting reductions of COC concentrations in surface water and groundwater probably would be greater under Alternatives 5a and 5c than under other alternatives. Groundwater and surface water use restrictions probably would be required initially; however, these restrictions probably would be less extensive and needed for a shorter period of time compared to other alternatives. Long-term water treatment requirements likely would be less under Alternatives 5a and 5c than under other alternatives. Because mine waste would be placed in the existing open pits below the level of groundwater outside of the pits, there would be some risk that poor quality groundwater could accumulate in the pits, similar to the situation in the existing backfilled pits. Drainage systems would be constructed in the pits prior to backfilling to reduce this risk.

Potential community impacts associated with transporting cover material would be reduced compared to other alternatives due to the smaller volume (estimated 400,000 cy under Alternative 5c and 600,000 to 800,000 cy under Alternative 5a) of material required for cover construction. Risks to workers and the potential for migration of contaminated sediments from the MA during construction would be greater under Alternatives 5a and 5c than under other alternatives due to the much greater extent of earthwork involved. Alternatives 5a and 5c would have the longest construction times and, consequently, the longest times to achieve RAOs for surface materials and air. Construction activities would have to be staged to limit releases of contaminated water after backfilling of Pit 3 starts, which could extend the construction time.

5.4.2 Compliance with ARARs

In this section, the alternatives are evaluated with regard to their compliance with the following potential ARARs:

- For surface water, Tribal water quality standards and federal recommended water quality criteria in the surface water system and at point discharges
- For groundwater outside of areas of waste containment, Tribal groundwater cleanup standards, SDWA drinking water standards, and UMTRCA groundwater protection standards
- For sediment, Tribal sediment cleanup standards
- For surface materials, Tribal soil cleanup standards and UMTRCA standards for radium activity concentrations
- For air, the NESHAPs radon flux standard

To comply with Tribal ARARs for protection of human health for surface water, groundwater, sediment, and surface materials, the concentrations of most COCs need to be reduced to approximately background, or the pathway eliminated.

If onsite sludge disposal is included under any of Alternatives 2b through 5c, an onsite sludge disposal facility would be designed and constructed to comply with the requirements of RCRA Subtitles C and D and the Tribal HSCA that are determined to be applicable or relevant and appropriate.

This ARARs analysis assumes that a WMA would be defined for the site that would encompass areas of the MA within which mine waste is contained. Restoration of groundwater would not be practicable within the WMA. When restoration of groundwater is not practicable, then it is necessary to prevent further migration of the plume and to prevent exposure to the contaminated groundwater (40 CFR.300.430[a][2]). The NCP provides that groundwater cleanup levels should generally be attained throughout the contaminated plume. However, the NCP recognizes that groundwater may remain contaminated at the edge of and within the WMA when waste is left in place (55 Fed. Reg. 8713, 8753, March 8, 1990). Groundwater quality standards would be potential ARARs downgradient of the WMA.

Each alternative, except Alternatives 1 and 2b, would comply with all potential ARARs. For surface water and for groundwater outside of the WMA, a period of recovery would be needed until compliance with ARARs is achieved. Although not quantitatively compared, the periods of recovery for different alternatives are compared qualitatively.

5.4.2.1 Alternative 1 (No Action)

Alternative 1 would not comply with potential surface water, groundwater, sediment, surface materials, or air ARARs. Currently, maximum concentrations of uranium, manganese, cadmium, copper, nickel, silver, and zinc exceed water quality standards at one or more locations in the mine drainages or Blue Creek. Under Alternative 1, exceedances of potential ARARs would continue or increase.

In groundwater, maximum concentrations of manganese and uranium currently exceed potential ARARs at MAA monitoring well locations. Under Alternative 1, concentrations of COCs in groundwater would probably increase compared to current conditions and the extent of the plume could increase.

In surface materials within the MA and within and adjacent to the haul roads, concentrations of lead, radium, and uranium exceed potential ARARs. Under Alternative 1, concentrations of COCs in surface materials would continue to exceed potential ARARs for the foreseeable future.

In sediment within Blue Creek, concentrations of manganese exceed potential ARARs. In the three drainages south of the MA and in the open pits, concentrations of lead, manganese, radium, and uranium exceed potential sediment ARARs. Under Alternative 1, concentrations of COCs in sediment would continue to exceed potential ARARs for the foreseeable future.

In air, radon flux within the MA would not comply with the 40 CFR 61 standard.

Because Alternative 1 does not meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs, it is eliminated from further consideration and is not included for comparison in the following subsections that discuss the balancing criteria.[17]

5.4.2.2 Alternative 2b (Institutional Controls and Ex-Situ Water Treatment)

Alternative 2b would not comply with all ARARs. As described under Alternative 1, one or more COCs exceed potential ARARs for surface water, groundwater, sediment, surface materials, and air. Under Alternative 2b, no additional controls would be used to reduce the levels of COCs in these media compared to current conditions. Although surface water, groundwater, and sediment quality may slowly improve over time, Alternative 2b would not comply with ARARs for the foreseeable future. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

5.4.2.3 Alternatives 3c (Above Grade Containment and Ex-Situ Water Treatment) and 3d (Above Grade Containment and In-Situ Water Treatment)

Alternatives 3c and 3d would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs.

Under Alternatives 3c and 3d, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 243 acres). Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. Within the WMA, institutional controls would prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Sediment with concentrations of COCs that exceed ARARs would be contained in place. Surface materials with concentrations of COCs that exceed ARARs would be contained beneath a protective cover, which would result in compliance with potential ARARs for these media. The cover would reduce radon flux to levels that would comply with potential ARARs for air.

[17] An alternative that does not meet an ARAR under federal environmental or state environmental or facility siting laws may be selected under appropriate circumstances as identified in the NCP (40 CFR 300(f)(1)(ii)(C)

5.4.2.4 Alternatives 4d (Partial Pit Backfill and In-Situ Treatment) and 4e (Partial Pit Backfill with Passive Drainage and Ex-Situ Water Treatment)

Alternatives 4d and 4e would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. In addition, modifications to the water treatment system may be required to meet surface water discharge ARARs under Alternative 4e and, if treatment in the WTP is required, under Alternative 4d.

Under Alternatives 4d and 4e, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 260 acres). Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. Within the WMA, institutional controls would prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Sediment and surface materials with concentrations of COCs that exceed ARARs would be excavated and disposed of beneath a protective cover within the MA, which would result in compliance with potential ARARs for these media. The cover would reduce radon flux to levels that would comply with potential ARARs for air.

5.4.2.5 Alternatives 5a (Complete Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) and 5c (Excavation of Backfilled Pits, Complete Pit Backfill, and Ex-Situ Water Treatment)

Alternatives 5a and 5c would comply with all ARARs at the completion of remedy construction, except for surface water and groundwater ARARs at some locations. A period of recovery that may be on the order of one to several decades would be needed to comply with potential surface water and groundwater ARARs. The recovery period may be somewhat shorter under Alternatives 5a and 5c than under Alternatives 3c, 3d, 4d, and 4e because sources of contaminated groundwater may be more effectively contained. Modifications to the water treatment system may be required to meet surface water discharge ARARs under Alternatives 5a and 5c.

Under Alternatives 5a and 5c, a WMA would be established that includes the areas of the MA within which mine waste would be contained (approximately 97 acres under Alternative 5a and approximately 80 acres under Alternative 5c). Groundwater within Blue Creek should continue to comply with ARARs. Concentrations of COCs in other areas outside of the WMA may be reduced to levels that comply with ARARs over time. The time frame for ARAR compliance may be on the order of one to several decades. Within the WMA, Alternatives 5a and 5c

includes institutional controls to prohibit installation of drinking water wells. If effective, the institutional controls would prevent exposure to the contaminated groundwater.

Sediment and surface materials with concentrations of COCs that exceed ARARs would be excavated and disposed of in the existing open pits beneath a protective cover, which would result in compliance with potential ARARs for these media. The cover would reduce radon flux to levels that would comply with potential ARARs for air.

5.4.3 Long-Term Effectiveness and Permanence

The primary tradeoffs with respect to the long-term effectiveness and permanence criterion are related to the extent to which the alternatives rely on institutional controls to reduce risk and protect the integrity of waste containment and the ability to effectively enforce these controls; the level of long-term water treatment O&M that would be necessary; and the long-term effectiveness of in-situ treatment methods used under Alternatives 3d and 4d.

Alternative 5a (Complete Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) and Alternative 5c (Excavation of Backfilled Pits, Complete Pit Backfill with Drain Wells, and Ex-Situ Water Treatment) are ranked highest for long-term effectiveness and permanence. These alternatives rely less on institutional controls to achieve protection of human health and protect the integrity of cover systems than other alternatives. The areas of institutional controls to protect the integrity of cover systems would be 80 acres under Alternative 5c and 97 acres under Alternative 5a. The surface water and sediment exposure pathways in the open pits would be eliminated. The areal extent and duration of surface water and groundwater use restrictions needed under these alternatives may be somewhat less than under other alternatives. Risks from exposure to surface materials, external radiation, radon, surface water, and groundwater would be as low, or lower, than under any other alternative.

Long-term O&M needed to treat and dispose of sludge associated with estimated annual averages of 13,000,000 gallons (Alternative 5a) and 10,000,000 gallons (Alternative 5c) is expected to be less than under other alternatives. Alternatives 5a and 5c potentially achieve the greatest level of hydraulic containment of mine waste and, as a result, potentially would provide the greatest protection of groundwater and surface water quality and require the least long-term O&M. However, long-term maintenance of the pit drainage systems would be needed and, if maintenance is unsuccessful, poor quality groundwater could accumulate in the pits, similar to the existing backfilled pits. In this case, an increased level of long-term water treatment O&M would be necessary.

Alternatives 3c (Above Grade Containment and Ex-Situ Water Treatment) and 4e (Partial Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) are ranked next highest for long-term effectiveness and permanence. These alternatives rely more on institutional controls to achieve protection of human health and protect the integrity of cover systems than Alternatives

5a and 5c. The areas of institutional controls to protect the integrity of cover systems would be 243 acres under Alternative 3c and 260 acres under Alternative 4e. The areal extent and duration of surface water and groundwater use restrictions needed under these alternatives may be somewhat greater than under Alternatives 5a and 5c. Under Alternative 4e, the surface water and sediment exposure pathways in the open pits would be eliminated. Under Alternative 3c, a fence would be used to prevent exposure, which would be less permanent.

Long-term O&M needed to treat and dispose of sludge associated with an estimated annual average of 38,000,000 gallons is expected to be more than under Alternatives 5a and 5c. The covers used under Alternatives 3c and 4e would reduce contact of water and air with mine waste compared to existing conditions, but would not be expected to achieve the same level of isolation as Alternatives 5a and 5c. Long-term maintenance of the pit drainage system would be required under Alternative 4e and, if maintenance is unsuccessful, poor quality groundwater could accumulate in the pits, similar to the existing backfilled pits. In this case, an increased level of long-term water treatment O&M would be necessary under Alternative 4e.

Alternatives 3d (Above Grade Containment and In-Situ Water Treatment) and 4d (Partial Pit Backfill and In-Situ Treatment) are ranked next highest for long-term effectiveness and permanence. These alternatives are similar to Alternatives 3c and 4e, except that the long-term adequacy and reliability of the in-situ water treatment measures under Alternatives 3d and 4d are less certain than the ex-situ water treatment systems under Alternatives 3c and 4e. Alternatives 3d and 4d would achieve reductions of risk from exposure to surface materials, external radiation, radon, surface water, and groundwater that are similar to Alternatives 3c and 4e. The long-term performance and maintenance requirements of the in-situ treatment actions included under both alternatives have not been demonstrated and would need to be evaluated using treatability studies. The potential exists for large reductions in O&M associated with sludge disposal. The treatment systems would require ongoing monitoring and would likely require future intervention in the form of replacing spent PRB reactive media (estimated every 15 years), reapplying pit lake amendments (estimated every 5 years), and supplementing amendments for mine waste in backfilled pits (estimated every 30 years). Alternative 4d would be subject to the same concerns with accumulation of poor quality groundwater in the pits as Alternative 4e, should in-situ treatment prove ineffective.

Alternative 2b (Institutional Controls and Ex-Situ Water Treatment) is ranked lowest for long-term effectiveness and permanence. Alternative 2b would rely more on institutional controls to achieve protection of human health than other alternatives, including access restrictions (fence) for the entire MA (350 acres). The fence would be a less reliable control for reducing human risk from exposure to surface materials, external radiation, and radon than the protective covers used under the other alternatives. Risks for ecological receptors generally would not be reduced compared to current conditions. Risks from surface water and groundwater, while significantly reduced compared to no action, would be higher than under other alternatives, and use restrictions would need to be enforced for the foreseeable future. The level of long-term O&M

needed to treat an estimated annual average of 80,000,000 gallons would be greater than under other alternatives.

5.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Each of the retained alternatives includes treatment to reduce the toxicity of contaminated water. Mine waste is contained under each of the alternatives, except Alternative 2b, and treatment of the mine waste is used only under Alternative 4d. The primary tradeoffs involve the types and volumes of residuals produced by water treatment. Potential remobilization of COCs is a consideration under Alternatives 4d and 3d. Table 5-23 summarizes estimated post-remedy water treatment and sludge generation quantities under each alternative. CERCLA and the NCP state a preference for treatment of principal threat waste; however, no principal threat waste has been identified at the site.

Alternative 4d (Partial Pit Backfill and In-Situ Treatment) is ranked highest for reduction of TMV through treatment. Alternative 4d potentially would eliminate, or greatly reduce, production of treatment residuals. In addition, the mobility of COCs in 1.5 million cy of ore and protore placed in Pit 3 and 400,000 cy of waste rock placed in Pit 4 would be reduced through development of circumneutral and reducing conditions in the pits. The primary drawback of Alternative 4d is that, should the pit water return to an oxidizing condition in the future, COCs could be remobilized.

Alternatives 2b, 3c, 4e, 5a, and 5c each would use the same water treatment process, achieve the same reduction in the toxicity of contaminated water, and produce residuals with the similar characteristics. They differ in the estimated volume of sludge produced. Listed from lowest to highest, the estimated average annual amounts of dewatered sludge produced under each alternative are: Alternative 5c (40 tons per year), Alternative 5a (80 tons per year), Alternatives 3c and 4e (220 tons per year), and Alternative 2b (470 tons per year).

Alternatives 3d (Above Grade Containment and In-Situ Water Treatment) is ranked lowest for reduction of toxicity, mobility, or volume through treatment. The PRBs included under Alternative 3d may produce a greater quantity of residuals (spent reactive media) per volume of water treated than ex-situ treatment. It should be noted that the estimated volume of residuals that would be produced under Alternative 3d is uncertain. Treatability studies would be needed to refine the estimate and might result in a lower estimate. There would be some potential for remobilization of COCs from the contaminated sediment that would be deposited in Pits 3 and 4 during in-situ pit water treatment under Alternative 3d. Alternative 3d would require only periodic replacement of spent PRB reactive media, while ex-situ water treatment would require ongoing management of sludge.

5.4.5 Short-Term Effectiveness

Short-term effectiveness tradeoffs primarily relate to three considerations. The first consideration is protection of the community during remedial actions. These risks would result primarily from hauling materials that would need to be imported to the MA for remedy construction and, to a lesser extent, hauling sludge to an offsite disposal facility, if offsite sludge disposal is used. The materials include soil needed for cover construction and, potentially, rock needed for drainage blanket construction. The risks would be greatest for Alternatives 3c, 3d, 4d, and 4e, which would need relatively large cover material volumes. Alternatives 5a and 5c would need less cover material, but may need large volumes of rock for drainage blanket construction if these materials cannot be segregated from waste rock. Alternative 2b would not need cover or drainage blanket material. Alternative 2b would result in the largest volumes of sludge and would involve the greatest risks to the community. Alternatives 3c and 4e would result in less sludge than Alternative 2b, and Alternatives 3d, 4d, 5a, and 5c would result in the smallest volumes of sludge.

The second consideration is protection of the workers during remedial actions. Risks to workers would result from earthmoving activities, operation of the water treatment plant, and onsite disposal of sludge, if onsite disposal is used. Alternatives 5a and 5c involve much larger volumes of earthwork than the other alternatives. Alternative 2b would result in the greatest risks to workers from operation of the water treatment plant and onsite sludge disposal; Alternatives 3c and 4e would have smaller risks, and Alternatives 3d, 4d, 5a, and 5c would have the smallest risks.

The third consideration is potential impacts to the environment, which include the potential for releases of contaminated sediment and water during construction. The potential for impacts generally increases with the scale of remedial actions and for alternatives that include backfilling the open pits, which are currently used to contain contaminated water and sediment. The potential impacts are lowest under Alternative 2b, which includes few remedial actions. The potential impacts are greater for Alternatives 3c and 3d, which include significant earthwork over an estimated 2 to 3 year period, but do not include backfilling the open pits. Alternatives 4d and 4e include somewhat larger volumes of earthwork over a longer period of time. Both alternatives include partially backfilling the open pits; however, under Alternative 4d the pits would still be available to contain contaminated water. The potential for environmental impacts is most significant for Alternatives 5a and 5c, which involve much more earthwork than the other alternatives and include complete backfilling of the open pits.

The fourth consideration is the time to achieve RAOs for surface materials and air, as well as RAOs for exposure of ecological receptors to surface water. The time to achieve RAOs for surface materials and air is longer for alternatives that involve large volumes of earthwork (Alternatives 5a and 5c and, to a lesser degree, Alternatives 4d and 4e). It is also potentially longer for Alternative 4d, which would require a treatability study and procurement of treatment

amendments before containment of ore and protore could be completed. A period of recovery would be needed under any alternative to achieve RAOs for exposure of ecological receptors to surface water. This time may be somewhat shorter under alternatives that include more complete isolation of mine waste (Alternatives 5a and 5c) than under other alternatives. RAOs for ecological protection generally would not be achieved within the foreseeable future under Alternative 2b.

Alternative 2b (Institutional Controls and Ex-Situ Water Treatment) is ranked highest for short-term effectiveness. Risks to the community and workers and impacts to the environment during remedial actions would be minimal. The primary risks would be associated with water treatment and sludge disposal, which could be managed using standard health and safety and materials handling practices. RAOs for protection of human health could be achieved within a single construction season through construction of a fence and implementation of institutional controls. The primary drawback to Alternative 2b is that RAOs for protection of ecological receptors would not be achieved within the foreseeable future, with the exception of surface materials RAOs for animals that could be excluded from the MA by the fence.

Alternative 3c (Above Grade Containment and Ex-Situ Water Treatment) and Alternative 3d (Above Grade Containment and In-Situ Water Treatment) are ranked next highest for short-term effectiveness. Risks to the community from hauling an estimated 1,300,000 to 1,900,000 cy of cover material would exceed those under Alternatives 2b, 5a, and 5c, but would be similar to Alternatives 4d and 4e. Risks to workers from regrading an estimated 5,400,000 cy of mine waste would exceed those under Alternative 2b and would be substantially less than under Alternatives 5a and 5c. The potential for releases of contaminated sediment and water during construction would exceed those associated with Alternative 2b, would be significantly less than those associated with Alternatives 4e, 5a, and 5c, and would be similar to those associated with Alternative 4d. Other potential environmental impacts would result from sediment remedial actions in the drainages under Alternatives 3c and 3d and construction of PRBs in the Western, Central, and Eastern drainages under Alternative 3d. The time to complete remedial actions within the MA and achieve RAOs for surface materials and air would be less than any other alternative except Alternative 2b, and could probably be completed within two to three construction seasons. RAOs for protection of ecological receptors from surface water may be achieved after a recovery period that may be on the order of one to several decades. This recovery period would be similar to Alternatives 4d and 4e, and may be somewhat longer than Alternatives 5a and 5c.

Alternative 4e (Partial Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) is ranked next highest for short-term effectiveness. Risks to the community and workers would be similar to Alternatives 3c and 3d. The potential for releases of contaminated sediment and water during construction would be greater than under Alternatives 3c and 3d because the open pits would not be available for water containment and the duration of construction activities may be somewhat longer. The time to complete remedial actions within the MA and achieve RAOs for

surface materials and air is estimated to be 3 to 4 years, which is approximately 1 year longer than Alternative 3c. Similar to Alternatives 3c and 3d, RAOs for protection of ecological receptors from surface water may be achieved after a recovery period that may be on the order of one to several decades.

Alternative 4d (Partial Pit Backfill and In-Situ Treatment) is ranked next highest for short-term effectiveness. Risks to the community and workers would be similar to those under Alternative 3c, 3d, and 4e. The potential for releases of contaminated sediment and water during construction would be somewhat less than under Alternative 4e, because the pits would still be available to contain contaminated water. The time to achieve RAOs for surface materials and air could be extended by the time required to dewater the open pits, consolidate ore and protore, conduct treatability and design studies, and obtain amendments for in-situ treatment. Similar to Alternatives 3c, 3d, and 4e, RAOs for protection of ecological receptors from surface water may be achieved after a recovery period that may be on the order of one to several decades.

Alternative 5a (Complete Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) and Alternative 5c (Excavation of Backfilled Pits, Complete Pit Backfill with Drain Wells, and Ex-Situ Water Treatment) are ranked lowest for short-term effectiveness. Risks to the community would be lower than under other alternatives because of the reduced volume of cover material (600,000 to 800,000 cy under Alternative 5a and 400,000 cy under Alternative 5c) that would be hauled to the site and the reduced sludge disposal requirements. However, part or all of the estimated 1,200,000 cy of rock needed for drainage blanket construction may need to hauled from offsite sources. Worker risks during remedial actions would be greater than under other alternatives because of the much larger volumes of earthwork involved. Similarly, the potential for releases of contaminated sediment and water during construction would be greater than under other alternatives because of the much larger volumes of earthwork involved and because the pits would be unavailable to contain contaminated water. The time to achieve RAOs for surface materials and air under Alternatives 5a and 5c would be extended by the time required to reconstruct the water treatment plant, dewater the open pits, and consolidate approximately 16.8 million (Alternative 5a) to 19 million (Alternative 5c) cy of mine waste in the open pits. The time frame to achieve RAOs for protection of ecological receptors from surface water may be somewhat shorter than under Alternatives 3c, 3d, 4d, and 4e, and would be much shorter than under Alternative 2b.

5.4.6 Implementability

The primary tradeoffs under the implementability criterion are related to five considerations. The first primary tradeoff is related to the availability of materials, including cover materials, drainage blanket materials, reactive media, and organic amendments. This consideration is greatest for Alternatives 3d and 4d, which require reactive media or amendments for in-situ treatment, as well as relatively large cover material volumes. This consideration would also be significant for Alternatives 3c and 4e, which also require relatively large cover material volumes.

Alternatives 5a and 5c require less cover material; however, large volumes of rock would be needed for construction of drainage blankets. It is uncertain whether adequate quantities of suitable material could be segregated from onsite waste rock. Materials availability is not a significant consideration under Alternative 2b, which does not require cover material. An administrative implementability consideration related to cover materials is the ability to obtain needed approvals to mine the material.

The second primary tradeoff is the technical feasibility of in-situ water treatment included under Alternatives 3d and 4d. In particular, the technical feasibility of the pit bioreactors included under Alternative 4d is undemonstrated. No other mine sites where pit bioreactors have been implemented on the same scale have been identified. Treatability studies would be needed to demonstrate the effectiveness of and design in-situ treatment systems. The need to conduct treatability studies could impact construction scheduling.

The third primary tradeoff is related to the ability to stage construction activities to contain or treat contaminated water. This consideration is most significant under Alternatives 5a and 5c, which include complete backfill of Pit 3 and Pit 4 and have the longest construction times. It is also a consideration under Alternative 4e.

The fourth primary tradeoff relates to the long-term availability of disposal sites for water treatment sludge and spent reactive media. Onsite disposal would need to comply with the requirements of the Tribe's HSCA that are determined to be applicable or relevant and appropriate. Offsite disposal at the Richland facility may become unavailable in the future if limitations on disposal of uranium^{238} are implemented. At that time, alternative disposal options would be needed and may be more costly. Alternative 2b would generate the largest volumes of water treatment sludge and would be most affected by disposal limitations. Alternatives 4d, 5a, and 5c would generate the smallest volumes of water treatment sludge and would be least affected by disposal limitations.

The fifth primary tradeoff relates to the capacity of the open pits to contain mine waste under Alternatives 5a and 5c. The capacity of the pits is a consideration under Alternative 5c and, to a lesser degree because of the smaller volumes involved, Alternative 5a.

Alternative 2b (Institutional Controls and Ex-Situ Water Treatment) is ranked highest for implementability. This alternative has few technical feasibility concerns. Materials needed to implement Alternative 2b would be available. No material would be needed for cover construction. The primary implementability concern is the long-term availability of a disposal site for an estimated average of 12,000 cubic feet per year of water treatment sludge.

Alternative 3c (Above Grade Containment and Ex-Situ Water Treatment) is ranked second highest for implementability. Alternative 3c has the fewest technical feasibility considerations of the alternatives, except Alternative 2b. Alternative 3c would require more cover material than

Alternatives 2b, 5a, and 5c, but would require similar volumes of cover material as the other alternatives. A disposal site for an estimated average of 6,000 cubic feet per year of water treatment sludge would be needed.

Alternative 4e (Partial Pit Backfill with Passive Drainage and Ex-Water Treatment) is ranked next highest for implementability. Alternative 4e would require similar volumes of suitable cover material and generate similar volumes of water treatment sludge as Alternative 3c. Because the open pits would be partially backfilled, Alternative 4e has greater logistical concerns than Alternative 3c related to staging construction to prevent releases of contaminated water. Specialized contractors and equipment would be required to construct and maintain the passive drains.

Alternative 5a (Complete Pit Backfill with Passive Drainage and Ex-Situ Water Treatment) is ranked next highest for implementability. Alternative 5a has less concern with availability of suitable cover material than other alternatives, except for Alternatives 2b and 5c, because of the smaller area that would be covered. However, an estimated 1,200,000 cy of suitable rock for construction of drainage blankets in Pit 3 and Pit 4 would be needed. It is uncertain whether adequate quantities of suitable material could be segregated from onsite waste rock. Because the open pits would be completely backfilled, Alternative 5a has greater logistical concerns than Alternatives 2b, 3c, 3d, 4d, and 4e related to staging construction to prevent releases of contaminated water, which could increase cost and extend the construction time. Concerns with sludge disposal would be reduced compared to Alternatives 2b, 3c, and 4e because less sludge would be generated. Specialized contractors and equipment would be required to construct and maintain the passive drains.

Alternative 5c (Excavation of Backfilled Pits, Complete Pit Backfill with Drain Wells, and Ex-Situ Water Treatment) is similar to Alternative 5a with respect to implementability. It is ranked somewhat lower than Alternative 5a for two reasons that relate to the larger volume of waste material that would be placed in the open pits. First, the capacity of the open pits to contain the mine waste would be more uncertain. Second, the increased construction time would increase the difficulty of containing contaminated water during construction. Considerations related to availability of materials for construction of covers and drainage blankets and sludge disposal would be similar to Alternative 5a.

Alternatives 3d (Above Grade Containment and In-Situ Water Treatment) and 4d (Partial Pit Backfill and In-Situ Treatment) are ranked lowest for implementability. The technical feasibility of in-situ water treatment included under these alternatives is not fully demonstrated. In particular, the technical feasibility of the pit bioreactors included under Alternative 4d is undemonstrated. No other mine sites where pit bioreactors have been implemented on the same scale have been identified. Both alternatives would require treatability studies and pilot-scale testing that could lead to schedule delays. In addition to concerns with the availability of suitable cover materials, which would be similar to Alternatives 3c and 4e, the alternatives would

have concerns with the availability of reactive media and treatment amendments. The availability of these materials could affect construction schedules and cost. Both alternatives potentially could reduce or eliminate sludge disposal considerations if in-situ water treatment meets RAOs.

5.4.7 Cost

For each alternative a range of costs is presented. A lower "base" cost was estimated assuming onsite disposal of water treatment sludge and low range cover materials costs. A higher "base plus incremental" cost was estimated assuming offsite disposal of water treatment sludge and high range cover material costs. Since the Spokane Tribe has voiced concern over on-site disposal and use of reservation resources for cover materials, the higher cost may be more probable. In addition, present worth costs and O&M costs were estimated for both base and base-plus-incremental assuming (1) a discount rate of 7 percent and a 30-year period of performance and (2) a discount rate of 3.1 percent and a 140-year period of performance. Estimated capital, annual O&M, and total present worth costs for each alternative are summarized in Table 5-24. The estimated total present worth costs for each alternative are shown in Figure 5-17.

In this section, the estimated costs of the alternatives are presented in order from the lowest estimated total present worth cost to the highest estimated total present worth cost, using base costs, a discount rate of 7 percent, and a 30-year period of performance. The relative costs of the alternatives depend on which combination of cost scenario (base or base plus incremental), period of performance, and discount rate is considered. The ranking, from lowest to highest, of the estimated total present worth costs of the alternatives under each combination of these cost parameters is shown in Table 5-25.

<u>Alternative 2b (Institutional Controls and Ex-Situ Water Treatment)</u>

Estimated capital cost = $4,800,000 (base) to $2,400,000 (base + incremental)

Estimated average annual O&M cost = $1,300,000 (base) to $3,800,000 (base + incremental)

Estimated periodic costs = $1,600,000 (year 10 and every 30 years thereafter)

Estimated total present worth cost (30, 7%) = 22,000,000 (base) to $44,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $49,000,000 (base) to $118,000,000 (base + incremental)

The estimated volumes of water needing treatment under Alternative 2b are the largest among the alternatives. As a result, the O&M costs are more sensitive to uncertainties related to future water treatment requirements and sludge disposal costs than other alternatives. These uncertainties include the volume and quality of water to be treated, the method (onsite or offsite) of sludge disposal, and the possible need for modifications to the WTP to remove sulfate. The cost for offsite sludge disposal could be reduced if disposal options that are more cost-effective than the Richland facility are identified. Such options may become available if the treatment system is modified to include pretreatment to remove uranium. Because the estimated annual O&M costs under Alternative 2b are large compared to capital costs, the period of performance and discount rate used to calculate present worth costs has a large effect on the estimated total present worth cost.

Alternative 3c (Above Grade Containment and Water Treatment)

Estimated capital cost = $65,000,000 (base) to $71,000,000 (base + incremental)

Estimated average annual O&M cost = $1,300,000 (base) to $2,600,000 (base + incremental)

Estimated periodic costs = $1,600,000 (year 10 and every 30 years thereafter)

Estimated total present worth cost (30, 7%) = 82,000,000 (base) to $101,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $108,000,000 (base) to $152,000,000 (base + incremental)

The major capital cost uncertainties under Alternative 3c are related to the cost of obtaining material for use in cover construction. Nearly 50% of the estimated total cost is related to cover construction and maintenance. The major O&M cost uncertainties under Alternative 3c are related to the volume and quality of water to be treated, the method (onsite or offsite) of disposal of water treatment sludge, and the possible need for modifications to the WTP to remove sulfate.

Alternative 4e (Partial Pit Backfill with Passive Drainage and Ex-Situ Water Treatment)

Estimated capital cost = $80,000,000 (base) to $86,000,000 (base + incremental)

Estimated average annual O&M cost = $1,300,000 (base) to $2,600,000 (base + incremental)

Estimated periodic costs = $1,600,000 (year 10 and every 30 years thereafter)

Estimated total present worth cost (30, 7%) = 97,000,000 (base) to $116,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $123,000,000 (base) to $167,000,000 (base + incremental)

The primary capital and O&M cost uncertainties under Alternative 4e are similar to those described under Alternative 3c. In addition, O&M costs for water treatment would increase if poor quality groundwater accumulates in Pit 3 and Pit 4, which would be partially backfilled under Alternative 4e.

Alternative 4d (Partial Pit Backfill and In-Situ Treatment)

Estimated capital cost = $106,000,000 (base) to $114,000,000 (base + incremental)

Estimated average annual O&M cost = $880,000 (base) to $1,900,000 (base + incremental)

Estimated periodic costs = $1,500,000 (year 30 and every 30 years thereafter)

Estimated total present worth cost (30, 7%) = 116,000,000 (base) to $136,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $135,000,000 (base) to $177,000,000 (base + incremental)

The major capital cost uncertainties under Alternative 4d are related to the cost of obtaining materials for use in cover construction and for use as amendments in the pit bioreactors.

The major O&M cost uncertainties are related to the need to further treat water discharged from the pit bioreactors. If further treatment is required, these uncertainties include the method (onsite or offsite) of disposal of water treatment sludge and any modifications to the water treatment system that may be needed to meet discharge RAOs.

Alternative 3d (Above Grade Containment and In-Situ Water Treatment)

Estimated capital cost = $97,000,000 (base) to $103,000,000 (base + incremental)

Estimated average annual O&M cost = $1,000,000 (base) to $1,300,000 (base + incremental)

Estimated periodic costs = $26,000,000 to $42,000,000 (year 15 and every 15 years thereafter); $130,000 (year 5 and every 5 years thereafter)

Estimated total present worth cost (30, 7%) = 123,000,000 (base) to $139,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $175,000,000 (base) to $218,000,000 (base + incremental)

The major cost uncertainties under Alternative 3d are related to the volume of reactive media required, the unit cost of the reactive media, and the unit cost for disposal of spent reactive media used in PRB construction. Because of these uncertainties, there is a significant possibility that actual costs would not be within the range of +50% to -30% of the estimated cost. However, in spite of the uncertainties, it is unlikely that Alternative 3d would be cost-effective unless the future loads of COCs in contaminated seep and groundwater flows treated in the PRBs are lower than those estimated in this FS.

The estimated volumes of water needing ex-situ treatment under Alternative 3d are small compared to other alternatives. As a result, the O&M costs are relatively insensitive to uncertainties related to future water treatment requirements and sludge disposal costs than other alternatives.

Alternative 5a (Complete Pit Backfill with Passive Drainage and Ex-Situ Water Treatment)

Estimated capital cost = $117,000,000 (base) to $118,000,000 (base + incremental)

Estimated average annual O&M cost = $820,000 (base) to $1,300,000 (base + incremental)

Estimated periodic costs = $1,600,000 (year 30 and every 30 years thereafter)

Estimated total present worth cost (30, 7%) = 127,000,000 (base) to $133,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $144,000,000 (base) to $159,000,000 (base + incremental)

The major capital cost uncertainties under Alternative 5a are related to the cost of earthwork, primarily consolidating ore, protore, and waste rock in Pit 3 and Pit 4. Capital costs could increase if drain rock must be imported from an offsite source.

The estimated volumes of water needing treatment under Alternative 5a are relatively low. As a result, the O&M costs are relatively insensitive to uncertainties related to future water treatment requirements and sludge disposal costs. However, O&M costs for water treatment would increase if poor quality groundwater accumulates in Pit 3 and Pit 4, which would be backfilled under Alternative 5a, or if water in the Western Drainage needs to be treated. Because the

estimated annual O&M costs under Alternative 5a are small compared to capital costs, the period of performance and discount rate used to calculate present worth costs have a relatively small effect on the estimated total present worth cost.

Alternative 5c (Excavation of Existing Backfilled Pits, Complete Pit Backfill, and Ex-Situ Water Treatment)

Estimated capital cost = $124,000,000 (base) to $125,000,000 (base + incremental)

Estimated average annual O&M cost = $650,000 (base) to $900,000 (base + incremental)

Estimated periodic costs = $1,600,000 (year 30 and every 30 years thereafter)

Estimated total present worth cost (30, 7%) = 132,000,000 (base) to $136,000,000 (base + incremental)

Estimated total present worth cost (140, 3.1%) = $146,000,000 (base) to $154,000,000 (base + incremental)

The major cost uncertainties under Alternative 5c are the same as under Alternative 5a.

5.5 SLUDGE DISPOSAL AND SULFATE REMOVAL

The long-term cost of water treatment will be primarily affected by two issues:

- The cost of offsite sludge disposal
- The potential need to remove sulfate to meet the Tribe's ceremonial and spiritual water quality standard (250 mg/L) in water discharged from the WTP

Costs presented for each alternative under the cost criterion in Sections 5.3 and 5.4 were estimated assuming that the sludge would be disposed of as low-level radioactive waste and do not include treatment to removal sulfate to the Tribe's water quality standard.

This section contains preliminary evaluations of the potential costs associated with making modifications to the water treatment system that would enable offsite disposal of the sludge as non-radioactive waste and would result in concentrations of sulfate in the discharge water that meet the Tribe's water quality standard. Section 5.5.1 presents background information on sludge disposal options and sulfate removal. Section 5.5.2 describes potential treatment trains and presents a preliminary evaluation of potential costs.

5.5.1 Background

As currently designed, the water treatment process produces sludge containing heavy metals (though the waste is not RCRA hazardous waste). It also contains concentrations of uranium that are licensable under NRC rules. The Tribe opposes onsite disposal of the sludge, and the Tribe's HSCA includes siting criteria that would prohibit onsite disposal. If taken offsite, the sludge would have to be disposed of in a licensed low-level radioactive waste facility, such as the U.S. Ecology facility in Richland, Washington. Processing the sludge for uranium extraction was investigated by DMC, but the nearest active mills are in Utah and Colorado, and both may be undergoing closure. It would require sustained high market values for uranium, and the removal of uranium requires acidification, which could make the sludge a RCRA toxicity characteristic leaching procedure hazardous waste.

An ion exchange (IX) step prior to the lime precipitation step could be added to remove the uranium, and regeneration of the ion exchange resin would produce uranium that could be marketable. Although the sludge from the subsequent lime precipitation step would no longer require LLRW disposal and would contain low levels of radium, the radium would soon exceed the Washington State radium limit for solid waste landfills of 0.1 microCuries per landfill. Hence, disposal of the sludge at a solid waste landfill in Washington would not be a viable option. Onsite disposal would still be prohibited under the Tribe's HSCA. However, the waste could be disposed of at a Subtitle C facility in Grandview, Utah, where "special wastes" are accepted. Table 5-26 presents a comparison of onsite and offsite sludge disposal using the nine CERCLA evaluation criteria.

The latter include a standard for sulfate of 250 mg/L. Sulfate in groundwater and surface water in the MA and MAA drainages exceeds the Tribe's water quality standard (250 mg/L) by a factor of 10 or more in some locations, due to ARD. EPA is evaluating this issue from a legal and policy standpoint. The current treatment system does not remove sulfate and discharges to the Eastern Drainage, where it constitutes the majority of flow for much of the year. The Tribe's water quality standards do not include provisions for establishing a mixing zone.

Assuming the sulfate standard must be met in WTP effluent, a nanofiltration step could be added to the treatment process to remove sulfate. Capital costs and treatment unit costs would increase, as would the total amount of residuals generated. As described above, the ion exchange units would produce marketable uranium when regenerated, and lime precipitation sludge would not be low-level radioactive waste. An additional waste stream would be generated from evaporation of concentrated reject water from the nanofiltration (following IX and lime precipitation). It would contain mostly salts, such as calcium sulfate and magnesium sulfate, and the mass of residual solids produced would be about six times that of the lime precipitation sludge. On site disposal of the "saltcake" waste stream may comply with HSCA and be acceptable to the Tribe, although the Council has issued a resolution to eliminate solid waste disposal facilities on reservation lands. If not ARAR-compliant, low-cost offsite disposal may

be possible at a nearby solid waste facility. It is not anticipated that nanofiltration would be used without the chemical precipitation step, unless onsite disposal was used. The large volume of residuals could not be disposed of offsite as solid waste, which would result in high costs for offsite disposal of residuals.

EPA is assessing other sulfate concentrations that may be protective and continues to evaluate the cost impacts of various treatment elements. The FS assumed current sulfate levels in post-remedy WTP influent; however, it is possible that sulfate levels will decline over time due to waste rock isolation from air and water. Combined with reduced effluent volumes, reductions in sulfate concentrations may reduce the extent of downstream exceedances of the Tribe's standard.

At this time, EPA has not identified a preference between onsite and offsite disposal due to legal and policy questions that must be resolved. The lowest cost approach is to use the current water treatment process and dispose of the sludge on site.

5.5.2 Description and Cost of Potential Treatment Train Options

Preliminary estimated costs have been developed for various combinations of water treatment processes and residuals disposal options (treatment trains) for the alternatives that do not include in-situ treatment (Alternatives 2b, 3c, 4e, 5a, and 5c). The costs presented in this section would need to be further evaluated using design-stage treatability studies. The treatment trains include both processes that would not remove sulfate and processes that would remove sulfate. The water treatment processes and residuals disposal options include the following.

<u>Treatment trains that would not remove sulfate</u>

- The existing chemical precipitation system with onsite disposal of dewatered sludge (years 1-3) and offsite disposal of dewatered sludge at U.S. Ecology Richland, Washington facility (year 4 to end). This scenario is equivalent to the base + incremental cost scenario.
- (1) Uranium removal using ion exchange with resin regeneration at an offsite mill (assumed to be located in Colorado) and (2) the existing chemical precipitation system, with disposal of the dewatered sludge at the U.S. Ecology Grandview, Idaho facility

<u>Processes that would remove sulfate</u>

- (1) Uranium removal using ion exchange with resin regeneration at an offsite mill (assumed to be located in Colorado); (2) the existing chemical precipitation system, with disposal of dewatered sludge at the U.S. Ecology Grandview, Idaho facility; (3) nanofiltration to remove sulfate; (4) evaporation of reject water in an onsite evaporation pond; and (5) disposal of residual salts at the Waste Management

Graham Road (Spokane, Washington) facility. This option includes an onsite evaporation pond, which may not be acceptable to the Tribe.

- (1) Uranium removal using ion exchange with resin regeneration at an offsite mill (assumed to be located in Colorado); (2) the existing chemical precipitation system with disposal of dewatered sludge at the U.S. Ecology Grandview, Idaho facility; (3) nanofiltration to remove sulfate; (4) evaporation of reject water in a mechanical evaporator and crystallizer; and (5) disposal of residual salts at the Waste Management Graham Road (Spokane, Washington) facility. This treatment train would have large power requirements for operation of the mechanical evaporator.

Estimated costs for water treatment and residuals disposal are shown in Table 5-27. These costs are used to develop estimated total costs for the alternatives, which are shown in Table 5-28. Unit costs used to develop the estimated costs for water treatment and residuals disposal are presented in Appendix D.

Design-stage treatability studies would be needed to fully evaluate the effectiveness and implementability of the treatment processes. For example, pretreatment may be needed to prevent scaling of the nanofiltration membrane or fouling of the ion exchange beds.

The estimated costs suggest that, with the possible exception of Alternatives 5a and 5c, use of ion exchange would result in long-term cost savings if offsite sludge disposal is required. The long-term cost savings would be greater for alternatives with larger treatment volumes. The estimated total cost savings for Alternative 2b range from 18% (30 years, 7% discount rate) to 27% (140 years, 3.1% discount rate). The estimated total cost savings for Alternatives 3c and 4e range from 3% (30 years, 7% discount rate) to 11% (140 years, 3.1% discount rate).

The estimated incremental cost to remove sulfate also depends on the volume of water to be treated. The estimated cost to evaporate the reject water using mechanical evaporation and crystallization was higher than the cost using evaporation ponds.

Table 5-1
Evaluation Criteria for Superfund Remedial Alternatives

Criterion		Description
Threshold criteria	Overall protection of human health and the environment	Determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.
	Compliance with ARARs	Evaluates whether the alternative meets federal, state, and tribal environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.
Balancing criteria	Long-term effectiveness and permanence	Considers the ability of an alternative to maintain protection of human health and the environment over time.
	Reduction of toxicity, mobility, or volume through treatment	Evaluates an alternative's use of treatment to reduce a) the harmful effects of principal contaminants, b) their ability to move in the environment, and c) the amount of contamination remaining after remedy implementation.
	Short-term effectiveness	Considers the length of time needed to implement an alternative and the risk the alternative poses to workers, residents, and the environment during implementation.
	Implementability	Considers the technical and administrative feasibility of implementing the alternative, including factors such as the availability of materials and services.
	Cost	Includes estimated present worth capital and operations and maintenance (O&M) costs. In this FS, O&M costs are estimated for a 30-year period using a discount rate of 7% and for a 140-year period using a discount rate of 3.1%.
Modifying criteria	Tribal acceptance	Considers whether the Tribe agrees with the EPA's analyses and recommendations, as described in the RI/FS and the Proposed Plan.
	Community acceptance	Considers whether the local community agrees with the EPA's analyses and recommendations. Comments received on the Proposed Plan during the public comment period are an important indicator of community acceptance.

Table 5-2
Factors (F(X%,Y)) for Estimating Present Worth O&M Costs for Various Values of Discount Rate and Period of Performance

Period of Performance (Y) (years)	Discount Rate (X%)				
	0%	3%	5%	7%	10%
30	2.4	1.6	1.2	1.0	0.8
50	4	2.1	1.5	1.1	0.8
100	8	2.5	1.6	1.1	0.8

Notes:
PW = present worth of O&M
PW (X%,Y) = F(X%,Y) * PW(7%,30)

Table 5-3
Overview Summary of Remedial Alternatives

Site Element	Alternative[1]						
	2b	**3c**	**3d**	**4d**	**4e**	**5a**	**5c**
Overview Description	Institutional Controls, Monitoring, and Continued Existing Water Treatment	Above-Grade Consolidation and Containment of Surface and Stockpiled Materials and Water Collection and Ex-Situ Treatment	Above-Grade Consolidation and Containment of Surface and Stockpiled Materials and In-Situ Groundwater and Pit Water Treatment	Amendment and Consolidation of Surface and Stockpiled Materials in Pits (Partial Backfill) and Water Treatment in Pit 3	Consolidation of Surface and Stockpiled Materials in Pits (Partial Backfill) with Pit Drains and Ex-Situ Water Treatment	Complete Backfill of Open Pits with Surface and Stockpiled Materials with Pit Drains and Ex-Situ Water Treatment	Excavation of Existing Backfilled Pits, Complete Backfill of Open Pits with Surface and Stockpiled Materials, with Pit Drains and Ex-Situ Water Treatment
Surface Water Management	Maintain existing surface water management system	Collect clean runoff from undisturbed and covered areas and convey to drainages south of MA	Same as 3c	Same as 3c	Same as 3c	Reestablish natural drainage patterns in Western Drainage; collect clean runoff from undisturbed and covered areas and convey to drainages south of MA	Reestablish natural drainage patterns in Western Drainage; establish drainage from existing backfilled pits in Central Drainage; collect clean runoff from undisturbed and capped areas and convey to drainages south of MA
Ore and Protore Stockpiles	Fence (entire MA) to prevent access	Consolidate above backfilled pits and cover (thick cover)	Same as 3c	Amend with lime and organic material and consolidate in Pit 3	Excavate and consolidate in Pit 3	Excavate and consolidate in open pits	Excavate and consolidate in open pits
South Spoils	Maintain existing soil cover and vegetation and fence (entire MA) to prevent access	Regrade to 3H:1V and cover (thin cover)	Same as 3c	Regrade to 3H:1V and cover (thin cover)	Same as 4d	Excavate and consolidate in open pits	Excavate and consolidate in open pits

Table 5-3 (Continued)
Overview Summary of Remedial Alternatives

Site Element	Alternative[1]						
	2b	3c	3d	4d	4e	5a	5c
Hillside Dump	Fence (entire MA) to prevent access	Regrade to 3H:1V and cover (thin cover)	Same as 3c	Partial consolidation in Pit 4; regrade to 3H:1V; and cover (thin cover)	Same as 4d	Excavate and consolidate in open pits	Excavate and consolidate in open pits
Other Waste Rock	Fence (entire MA) to prevent access	Regrade to 3H:1V and cover (thin cover); establish natural drainage patterns	Same as 3c	Same as 3c	Same as 3c	Excavate and consolidate in open pits. Excess waste rock would be mounded over the existing backfilled pits area to enhance runoff.	Excavate and consolidate in open pits
Backfilled Pits	No action	Recontour using ore and protore and cover (thick cover); pump and treat groundwater	Recontour using ore and protore and cover (thick cover); outflow from pits treated in-situ using PRBs where it emerges in seeps and groundwater in MAA.	Regrade and cover (thin cover); outflow from pits collected where it emerges in seeps and groundwater in MAA and treated in Pit 3	Regrade and cover (thin cover); outflow from pits collected where it emerges in seeps and groundwater in MAA and treated in WTP	Cover (thin cover) and install gravity drain to Pit 3	Excavate and consolidate in open pits

Table 5-3 (Continued)
Overview Summary of Remedial Alternatives

Site Element	Alternative[1]						
	2b	3c	3d	4d	4e	5a	5c
Pit 3	Leave open, pump and treat water to maintain minimum 3 feet cover over sediment	Leave open, pump to control water level, pumped water treated in WTP, sediment left in place	Leave open, treat water in-situ using lime addition, allow water level to rise as water quality improves, sediment left in place	Partial backfill with amended (with lime and organic material) ore and protore and cover (thick cover); sediment buried beneath fill	Excavate sediment; install passive drain, with discharge conveyed to WTP for treatment; partial backfill with ore, protore, and sediment; and cover (thick cover)	Complete backfill with ore, protore, and waste rock and cover (thin cover); install passive drain, with discharge conveyed to WTP for treatment	Complete backfill with ore, protore, and waste rock and cap (composite cap). Includes basal FML and dewatering wells; mound excess material above pit at slope no steeper than 3H:1V.
Pit 4	Leave open, pump and treat water to maintain minimum 3 feet cover over sediment	Leave open, pump to control water level, pumped water treated in WTP, sediment left in place	Same as 3c	Partial backfill with waste rock from Hillside Dump and cover (thin cover); sediment buried beneath fill	Excavate sediment; install passive drain from pit bottom to discharge east of MA; partial backfill with waste rock and sediment; and cover (thin cover)	Complete backfill with waste rock and cover (thin cover); install passive drain	Complete backfill with ore, protore, and waste rock and cap (composite cap). Includes basal FML and dewatering wells; mound excess material above pit at slope no steeper than 3H:1V.
Pit Highwalls	Fenced to prevent access	Fenced to prevent access	Same as 3c	Height reduced by partial backfill; fenced to prevent access; runoff collected in perimeter drain for treatment	Same as 4d	Pit highwalls eliminated by complete backfill	Pit highwalls eliminated by complete backfill

Table 5-3 (Continued)
Overview Summary of Remedial Alternatives

Site Element	Alternative[1]						
	2b	3c	3d	4d	4e	5a	5c
Cover Areas	No additional cover areas included	Thin cover = 210 acres Thick cover = 33 acres	Same as 3c	Thin cover = 243 acres Thick cover = 19 acres	Thin cover = 243 acres Thick cover = 15 acres	Thin cover = 97 acres Thick cover = 0 acres 1 ft thick soil cover over excavated areas to enhance revegetation (120 acres)	Thin cover = 0 acres Composite cap = 80 acres
Water Treatment	Existing system, with onsite or offsite sludge disposal after closure of Ford facility	Existing system, modified as necessary to achieve surface water RAOs, with onsite or offsite sludge disposal after closure of Ford facility	In-situ treatment; polishing of water from open pits using existing system with onsite or offsite sludge disposal after closure of Ford facility	Treat water in-situ in Pit 3. Collect and treat any pit discharge water exceeding water quality standards using existing system.	Existing system, modified as necessary to achieve surface water RAOs, with onsite or offsite sludge disposal after closure of Ford facility.	Existing system, modified as necessary to achieve surface water RAOs, with onsite or offsite sludge disposal after closure of Ford facility (as needed)	Existing system, modified as necessary to achieve surface water RAOs, with onsite or offsite sludge disposal after closure of Ford facility (as needed)
South Spoils Seeps	Collect and treat	Collect and treat, to the extent seeps exist after cover is placed	Treat in-situ using PRBs, to the extent seeps exist after cover is placed	Collect and treat in Pit 3, to the extent seeps exist after cover is placed.	Collect and treat, to the extent seeps exist after cover is placed.	Collect and treat, to the extent seeps exist and exceed water quality standards after consolidation and covering is implemented	Collect and treat, to the extent seeps exist and exceed water quality standards after consolidation and capping is implemented
Other MAA Seeps and Groundwater	Use restrictions	Collect and treat ex-situ, with use restrictions until RAOs are achieved	Treat in-situ using PRBs with use restrictions until RAOs are achieved	Collect and treat in Pit 3, with use restrictions until RAOs are achieved	Same as 3c	Use restrictions until RAOs are achieved	Same as 5a

Table 5-3 (Continued)
Overview Summary of Remedial Alternatives

Site Element	Alternative[1]						
	2b	**3c**	**3d**	**4d**	**4e**	**5a**	**5c**
MAA Sediments	No action (natural recovery)	Combination of containment and biostabilization	Same as 3c	Excavate hot spots and dispose in pits	Same as 4d	Same as 4d	Same as 4d
Haul Roads	Gated with warning signs	Pave roads	Same as 3c	Excavate and dispose in pits	Same as 4d	Same as 4d	Same as 4d

Note:
[1]Alternative 1 is not included in this table because it includes no action for all site elements.

Table 5-4
Summary of Institutional and Access Controls

Institutional control	Alternative						
	2b	3c	3d	4d	4e	5a	5c
Access restrictions (fence)	Entire MA; haul roads gated	Open pits (67 acres) WTP (3 acres) Onsite sludge disposal area (if used) (2 acres)	Open pits (67 acres) WTP (3 acres) Onsite sludge disposal area (if used) (2 acres)	Open pit highwalls WTP (3 acres)[3] Onsite sludge disposal area (if used) (2 acres)[3]	Open pit highwalls WTP (3 acres) Water storage pond (10 acres) Onsite sludge disposal area (if used) (2 acres)	WTP (3 acres) Water storage pond (5 acres) Onsite sludge disposal area (if used) (1 acre)	WTP (3 acres) Water storage pond (5 acres) Onsite sludge disposal area (if used) (1 acre)
Boulder barriers	None	Cover area (243 acres)	Cover area (243 acres)	Cover area + pits (310 acres)	Cover area + pits (310 acres)	Cover area (97 acres)	Cover area (80 acres)
Other cover protection ICs (residential and industrial use prohibition; excavation prohibition)	None (residential use would be prohibited in impacted areas adjacent to haul roads)	Cover area (243 acres) Haul roads	Cover area (243 acres) Haul roads	Cover area + pits (310 acres)	Cover area + pits (310 acres)	Cover area (97 acres)	Cover area (80 acres)
Groundwater use restrictions (MA and MAA drainages)[1]	Entire MA; MAA drainages (foreseeable future)	Cover areas (foreseeable future); Other MA areas, MAA drainages (as needed)[2]	Cover areas (foreseeable future); Other MA areas, MAA drainages (as needed)[2]	Cover areas (foreseeable future); Other MA areas, MAA drainages (as needed)[2]	Cover areas (foreseeable future); Other MA areas, MAA drainages (as needed)[2]	Cover areas (foreseeable future); Other MA areas, MAA drainages (as needed)[2]	Cover areas (foreseeable future); Other MA areas, MAA drainages (as needed)[2]
Surface water use restrictions and advisories (MAA drainages)[1]	For foreseeable future	Until background COC levels achieved[2]	Until background COC levels achieved[2]	Until background COC levels achieved[2]	Until background COC levels achieved[2]	Until background COC levels achieved[2]	Until background COC levels achieved[2]

Table 5-4 (Continued)
Summary of Institutional and Access Controls (Continued)

Institutional control	Alternative						
	2b	3c	3d	4d	4e	5a	5c
Surface water use restrictions and advisories (Blue Creek)[1]	For foreseeable future	None anticipated after initial recovery period[4]	None anticipated after initial recovery period[4]	None anticipated after initial recovery period[4]	None anticipated after initial recovery period[4]	None anticipated after initial recovery period[4]	None anticipated after initial recovery period
Sediment exposure advisories (signs and public notices)[1]	For foreseeable future	None anticipated	None anticipated	None anticipated	None anticipated	None anticipated	None anticipated
Plant and game ingestion advisories (signs and public notices)[1]	For foreseeable future	Required initially; duration unknown	Required initially; duration unknown	Required initially; duration unknown	Required initially; duration unknown	Required initially; duration unknown	Required initially; duration unknown

Notes
[1]Monitoring would be needed to determine the need for and duration of use restrictions and/or advisories
[2]The time frame that restrictions and advisories would be necessary may be on the order of one to several decades
[3]These access restrictions would be necessary if waters discharged from the pit bioreactors requires further treatment in the WTP
[4]Periodic restrictions on use for ceremonial and spiritual use may be needed during base flow conditions for a longer time frame due to sulfate discharged from the WTP

Table 5-5
Estimated Cover Material Requirements

Alternative	Cover Areas, acres		Estimated Material Volume, cy[8]							
	High flux	Low flux	Topsoil	ET Cover		FML Cover[4]	Multi-layer clay cover[5]		2-Layer ET/Waste Rock Cover[6]	
				Loam Only[1]	Sand Only[2]	Sand	Clay	Sand	Loam Only	Sand Only
3c,3d	33	210	300,000	1,000,000	1,600,000	Not evaluated	420,000	1,300,000	800,000	1,300,000
4d,4e	19	243	300,000	1,000,000	1,600,000	Not evaluated	470,000	1,400,000	900,000	1,400,000
5a[7]	0	97	100,000	300,000	500,000	Not evaluated	170,000	520,000	Not applicable	
5c	0	80	100,000	Not evaluated		300,000	Not evaluated		Not applicable	

Notes
ET - evapotranspiration
FML - flexible membrane liner
1. 5 ft thick over high flux areas, 2 ft thick over low flux areas.
2. Fine sand with a minimum of 10% fines, 9 ft thick over high flux areas, 3 ft thick over low flux areas
3. Topsoil would be used with the ET cover, the multi-layer clay cover, and the 2-layer ET/waste rock cover. Alternatively, the upper 18 inches of soil could be amended with clay to provide a suitable growth medium.
4. FML cover is FML with 2.7 feet thick soil cover.
5. Multi-layer clay cover is 1 ft of clay with 3 ft soil cover.
6. 2-layer ET/waste rock cover consists of ET cover over suitable waste rock from Hillside Dump in high flux areas
7. Materials volumes do not include any imported fill required to support revegetation of areas from which waste materials have been removed. For FS analysis, it is assumed 120 acres would require an average of 1 ft of imported fill to support revegetation (200,000 cy).
8. Materials volumes are calculated as the product of cover area (not slope corrected) and material thickness, and are increased by 10% to account for sloping surfaces.

Table 5-6
Summary of Conceptual Cover Parameters

Parameter	Existing Conditions[1]	Thin Cover		Thick Cover	
		Top	Slope	Top	Slope
Thickness, minimum, feet[3]	0	2.7	2.7	5.7	5.7
Thickness, maximum, feet[3]	0.7	3.7	3.7	9.7	9.7
Slope	Varies	3%	33%	3%	33%
Precipitation, inches	19.4	19.4	19.4	19.4	19.4
Runoff, inches (%)	3.0 (16%)	3.0 (15%)	3.9 (20%)	3.0 (15%)	3.7 (19%)
Evapotranspiration, inches (%)	4.1 (21%)	12.7 (65%)	12.5 (64%)	12.8 (66%)	12.8 (66%)
Percolation, inches (%)	12.3 (63%)	3.5 (18%)	2.9 (15%)	3.4 (18%)	2.7 (14%)
Reduction of percolation compared to existing conditions	Not applicable	72%	76%	72%	78%
Average radon flux, waste rock, $pCi/m^2/s$	32[2]	<20	<20	Not used	Not used
Average radon flux, ore and protore, $pCi/m^2/s$	140[2]	Not used	Not used	<20	<20

Notes
1. Runoff, evapotranspiration, and percolation for existing conditions are area-weighted averages for the parts of the MA that contribute to the South Spoils seeps, estimated using HELP modeling (EPA 2002b)
2. Direct measurement of flux (EPA 2005)
3. Cover thicknesses for the thin cover and thick cover include 8 inches (0.7 feet) of topsoil.

Table 5-7
Comparison of Concentrations of COCs in Surface Water to Potential ARARs for Protection of Human Health

Constituent	Units	95UTL Background	Numerical Standards				Range of COC Concentrations in MAA					
			Tribal WQS[b]	Tribal WQS Ceremonial & Spiritual	SDWA Primary DWS	Clean Water Act	Middle Blue Cr	Lower Blue Cr	Upper Eastern Drainage	Lower Eastern Drainage	Central Drainage	Western Drainage
Total Inorganics												
Manganese	ug/L	**72**	--	50	--	100	**9-1,070**	**26.2-90.3**	**4.3-15,900**	**346-5,840**	**40,100-91,200**	**99-15,900**
Uranium	ug/L	**20**	0.45[c]	--	30	--	**7-100**	**7-27**	**30-130**	**32.9-81**	**5-727**	**97-103**
Radionuclides												
Lead[210]	pCi/L	**2.5**	0.01	--	--	--	-5.4-17[a]	-0.50-<2.3	-3.4-14[a]	-15	0.0-62[a]	0.16-0.16
Uranium [234]	pCi/L	**8.8**	5.0	--	--	--	**1.4-46**	**3.0-9.7**	**7.2-64**	**9.7-73**	**1.54-360**	**2.5-38.1**
Uranium [238]	pCi/L	**7.6**	0.30	--	--	--	**2.42-32**	**2.3-8.8**	**6.5-58**	**8.9-72**	**<0.735-360**	**1.6-34.4**

No standard
Bolded values indicate maximum value exceeds background as determined in the RI and the lowest numerical standard
Bolded and shaded values represent potential ARARs and are the lowest numerical standard or background, whichever is higher
[a] The maximum concentration or activity is reported from SMI samples
[b] Tribal water quality standard for protection of human health for consumption of water and organisms
[c] Calculated from the Tribal WQS for Unat = 0.30 pCi/L

Table 5-8
Comparison of Concentrations of Risk Drivers in Surface Water to Potential ARARs for Protection of Aquatic Organisms

Constituent	Units	95UTL Background	Numerical Standards[a]		Range of Concentrations of Risk Drivers in MAA					
			Tribal WQS	CWA	Middle Blue Cr	Lower Blue Cr	Upper Eastern Drainage	Lower Eastern Drainage	Central Drainage	Western Drainage
Total Inorganics										
Aluminum	ug/L	**9,073**	87	--	50-6,740	<63.6-3,980	<30-2,150	<60-1,780	830-1,720	170-4,130
Dissolved Inorganics										
Cadmium	ug/L	**0.5**	1.03[b]	0.25[b]	<0.20-<1.0	<0.20-<0.50	<0.20-4.0[c]	**<0.2-4.0**	**28-54**	**0.99-5.2**
Copper	ug/L	2.6	**8.96[b]**	9.0[b]	<0.50-37[c]	<0.40-<4.8	<0.50-50[c]	<0.50-50[c]	**1.3-47**	**<0.9-80**
Lead	ug/L	1.2	**2.52[b]**	2.5[b]	<0.20-1.1	<0.90-1.1	<0.20-3.2	<0.20-<2.0	0.20-0.20	<0.2-<10
Nickel	ug/L	1.4	**52[b]**	52[b]	3.3-30	<3.4-4.4	**0.74-340**	**7.1-190**	**730-1,400**	**<20-380**
Silver	ug/L	0.9	3.45[b]	**3.2[b]**	<0.7-20[c]	<0.70-<0.80	**<0.7-30**	<0.7-30[c]	**<0.7-12**	**<0.8-7**
Zinc	ug/L	14	**105[b]**	120[b]	<3.0-40	<2.3-6.5	<0.40-370[c]	**<4-115**	**740-1,480**	**30-460**

Notes:
-- No standard
Bolded values indicate maximum value exceeds background as determined in the RI and the lowest numerical standard
[a] Standards listed are for chronic exposure
[b] Standard is hardness-dependent; the ARAR is the equation used to calculate the standard. Value shown is for a hardness of 100 mg/L as calcium carbonate.
[c] The maximum concentration or activity is reported from SMI samples
Bolded and shaded values represent potential ARARs and are the lowest numerical standard or background, whichever is higher
There are no potential ARARs for protection of aquatic organisms for the risk drivers barium, beryllium, cobalt, manganese, and uranium.

Table 5-9
Comparison of Concentrations of COCs in Groundwater to Potential ARARs

Constituent	Units	95 UTL Background	Numerical Standards			Range of COC Concentrations in MAA alluvium			
			Tribal HSCA	SDWA DWS	UMTRCA	Middle Blue Cr	Eastern Drainage	Central Drainage	Western Drainage
Metals									
Manganese	ug/L	**1,990**	1,090	--	--	166	0.47-3,720[a]	**1,060-34,700**	**15,400-40,200**
Uranium (total)	ug/L	**88**	4.67	30	--	38	2-41	**1,020-1,020**	**78-2,980**
Radionuclides									
Uranium^{234}	pCi/L	**37**	--	--	30	14.4	0.60-15.2	**41.3-970**	**28.7-1,210**
Uranium^{238}	pCi/L	**35**	0.23	--	30	12.6	0.30-13.7	**39.4-957**	**25.8-1,016**

Notes:
-- No standard
Bolded values indicate maximum value exceeds background as determined in the RI and lowest the numerical standard
Bolded and shaded values represent potential ARARs and are the lowest numerical standard or background, whichever is higher
[a] The maximum concentration or activity exceeding the background limit is reported from E&E samples

Table 5-10
Comparison of Concentrations of COCs in Surface Materials to Potential ARARs

Constituent	Units	95 UTL Background	Numerical Standards		Range of COC Concentrations		
			Tribal HSCA	UMTRCA	Mined Area	East and West Haul Roads	Areas Adjacent to East and West Haul Roads
Total Inorganics							
Uranium	mg/kg	**43**	8	--	**12.6-482**	**72.7-262**	**6.98-93**
Radionuclides							
Lead^{210}	pCi/g	**7.5**	0.0368	--	**20-260**	**10.6-70**	**<1.2-41.9**
Radium^{226}	pCi/g	**4.7**	0.134	9.7	**0.074-880**	**15.4-35.4**	**11.5-59**

Notes:
-- No standard
Bolded values indicate maximum value exceeds background as determined in the RI and the lowest numerical standard
Bolded and shaded values represent potential ARARs and are the lowest numerical standard or background, whichever is higher

Table 5-11
Comparison of Concentrations of COCs in Sediment to Potential ARARs for Protection of Human Health

Constituent	Units	95 UTL Background	Numerical Standards	Range of COC Concentrations						
			Tribal HSCA	Open Pits	Middle Blue Cr	Lower Blue Cr	Upper Eastern Drainage	Lower Eastern Drainage	Central Drainage	Western Drainage
Total Inorganics										
Manganese	mg/kg	1,179	**1,870**	**629-2,160**	**560-63,300**	**414-3,670**	**199-2,490**	**6,040-33,600**	**983-6,910**	**72.3-12,900**
Uranium	mg/kg	**93**	8	**179-917**	3.59-89.9	4.23-28.6	5.4-57.5	**17.1-138**	**144-4,140**	**27.2-293**
Radionuclides										
Lead^{210}	pCi/g	**20**	0.0368	**62-130**	2.2-6.3	1.1-2.4	5.1-12.0	3.3-9.0	**2.3-23**	3.2-13
Radium^{226}	pCi/g	**13**	0.134	**<0.912-122**	<0.395-7.25	<0.41-1.95	<0.751-12.9	**<0.123-20**	**<0.545-263**	**<0.453-16.1**
Uranium^{238}	pCi/g	**31**	0.466	**92-305**	1.2-30	<0.648-8.26	1.8-19.7	**5.7-45.7**	**40.1-1,550**	**6.4-110**

Notes:
-- No standard
Bolded values indicate maximum value exceeds background as determined in the RI and the lowest numerical standard
Bolded and shaded values represent potential ARARs and are the lowest numerical standard or background, whichever is higher
There are no potential ARARs for the COC uranium^{234}

Table 5-12
Estimated Costs - Alternative 2b

ESTIMATED DIRECT CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Fencing	LF	22,500	$ 37	$ 830,000
Sludge disposal cell	LS	1	$ 1,500,000	$ 1,500,000
Filter press	LS	1	$ 350,000	$ 350,000
Unlisted Items	LS		10%	$ 300,000
Total Estimated Direct Capital Cost				**$ 3,000,000**

ESTIMATED INDIRECT CAPITAL COSTS

Contingency (30% of direct capital cost)	$ 900,000
Non-construction Costs (Engineering, etc) (30% of direct capital cost)	$ 900,000
Total Estimated Indirect Capital Cost	**$ 1,800,000**
Total Estimated Capital Cost	**$ 4,800,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Fence maintenance	2% of direct capital cost			1-140	$ 16,600	$ 210,000	$ 500,000
Cover and storm water system maintenance	LS	1	$ 20,000	1-140	$ 20,000	$ 200,000	$ 600,000
Treatment system O&M	Mgal/yr	80	$ 8,400	1-140	$ 700,000	$ 8,700,000	$ 22,300,000
Sludge disposal 2005-2007	tons/yr	1,400	$ 30	1-3	$ 42,000	$ 110,000	$ 100,000
Onsite sludge disposal 2008-2035	tons/yr	470	$ 30	4-140	$ 14,000	$ 140,000	$ 400,000
Onsite sludge disposal cell	2% of direct capital cost			4-140	$ 30,000	$ 290,000	$ 900,000
Treatment system replacement (periodic cost)	LS	1	$ 1,200,000	10, 40, 70, 100, 130	$ 1,200,000	$ 610,000	$ 1,500,000
Monitoring	LS	1	$ 245,000	1-140	$ 245,000	$ 3,000,000	$ 7,800,000
Subtotal, O&M costs (annual costs do not include periodic costs)					$ 1,000,000	$ 13,000,000	$ 34,000,000
Contingency (30%)					$ 300,000	$ 3,900,000	$ 10,200,000
Total Estimated O&M Cost					**$ 1,300,000**	**$ 17,000,000**	**$ 44,000,000**
TOTAL ESTIMATED NET PRESENT WORTH COST						**$ 22,000,000**	**$ 49,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-12 (Continued)
Estimated Costs - Alternative 2b

ESTIMATED INCREMENTAL COST FOR OFFSITE SLUDGE DISPOSAL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Sludge disposal cell	LS	1	$ (1,500,000)	$ (1,500,000)
Indirect Capital Cost				$ (900,000)
Total Estimated Incremental Capital Cost				$ (2,400,000)

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Sludge disposal 2011-2035	tons/yr	470	$ 4,000	4-140	$ 1,900,000	$ 19,000,000	$ 55,000,000
Contingency (30%)					$ 570,000	$ 5,700,000	$ 17,000,000
Total Estimated Incremental O&M Cost					$ 2,500,000	$ 25,000,000	$ 72,000,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR OFFSITE SLUDGE DISPOSAL **$ 23,000,000** **$ 70,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 2,400,000**	**$ 2,400,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 3,800,000**	**$ 42,000,000**	**$ 116,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 44,000,000**	**$ 118,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-13
Expanded Groundwater Collection and Treatment Under Alternatives 3c, 4d, and 4e

Groundwater Discharge Area	Estimated Existing Discharge[1] (gpm)	Percent Collected	Collection Rate, gpm
Backfilled Pits	5	100	5
Western Drainage in PIA	11	50	5
Central Drainage	0.4	100	0.4
Eastern Drainage	9	50	5
Between confluences	3	50	2
Confluence to Blue Cr	8	50	4
Blue Cr below confluence	21	0	0

Note:
[1]Estimated long-term average discharge rates from EPA 2002a, Phase 1 Hydrologic Modeling Technical Memorandum.

Table 5-14
Estimated Costs - Alternative 3c

ESTIMATED DIRECT CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Fencing	LF	7,500	$ 37	$ 300,000
Boulder barriers	LF	22,500	$ 2.47	$ 60,000
Regrading	CY	3,800,000	$ 1.64	$ 6,200,000
Consolidation, above grade	CY	1,200,000	$ 1.98	$ 2,400,000
Capping, thick	AC	33	$ 167,000	$ 5,500,000
Capping, thin	AC	210	$ 92,000	$ 19,000,000
Collection trench	LF	1,650	$ 100	$ 200,000
Expanded water collection system	LS	1	$ 750,000	$ 750,000
Filter press	LS	1	$ 350,000	$ 350,000
Sludge disposal cell	LS	1	$ 1,500,000	$ 1,500,000
Stormwater system	LF	20,000	$ 19	$ 400,000
Biostabilization, MAA sediments	LF	15,000	$ 100	$ 1,500,000
Paving, haul roads	LF	17,100	$ 27	$ 500,000
Unlisted Items	LS		5%	$ 1,900,000
Total Estimated Direct Capital Cost				**$ 41,000,000**

ESTIMATED INDIRECT CAPITAL COSTS

Contingency (30% of direct capital cost)	$ 12,000,000
Non-construction Costs (Engineering, etc) (30% of direct capital cost)	$ 12,000,000
Total Estimated Indirect Capital Cost	**$ 24,000,000**
Total Estimated Capital Cost	**$ 65,000,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Fence maintenance	2% of direct capital cost			1-140	$ 6,000	$ 70,000	$ 200,000
Cover maintenance	1% of direct capital cost			1-140	$ 250,000	$ 3,100,000	$ 8,000,000
Treatment system O&M	Mgal/yr	38	$ 8,400	1-140	$ 320,000	$ 4,000,000	$ 10,200,000
Sludge disposal 2005-2007	tons/yr	670	$ 30	1-3	$ 20,000	$ 50,000	$ 100,000
Onsite sludge disposal 2008-2035	tons/yr	220	$ 30	4-140	$ 6,600	$ 60,000	$ 200,000
Onsite sludge disposal cell	2% of direct capital cost			4-140	$ 30,000	$ 290,000	$ 900,000
Treatment system replacement (periodic cost)	LS	1	$ 1,200,000	10, 40, 70, 100, 130	$ 1,200,000	$ 610,000	$ 1,500,000
Expanded collection system O&M	5% of direct capital cost			1-140	$ 47,500	$ 590,000	$ 1,500,000
Biostabilization O&M	5% of direct capital cost			1-140	$ 75,000	$ 930,000	$ 2,400,000
Monitoring	LS	1	$ 245,000	1-140	$ 245,000	$ 3,000,000	$ 7,800,000
Subtotal, O&M costs (annual costs do not include periodic costs)					$ 980,000	$ 13,000,000	$ 33,000,000
Contingency (30%)					$ 290,000	$ 3,900,000	$ 9,900,000
Total Estimated O&M Cost					**$ 1,300,000**	**$ 17,000,000**	**$ 43,000,000**
TOTAL ESTIMATED NET PRESENT WORTH COST						**$ 82,000,000**	**$ 108,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-14 (Continued)
Estimated Costs - Alternative 3c

ESTIMATED INCREMENTAL COST FOR OFFSITE SLUDGE DISPOSAL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Sludge Disposal Cell	LS	1	$ (1,500,000)	$ (1,500,000)
Indirect Capital Cost				$ (900,000)
Total Estimated Incremental Capital Cost				$ (2,400,000)

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Sludge disposal 2008-2035	tons/yr	220	$ 4,600	4-140	$ 1,000,000	$ 10,000,000	$ 29,000,000
Contingency (30%)					$ 300,000	$ 3,000,000	$ 8,700,000
Total Estimated Incremental O&M Cost					$ 1,300,000	$ 13,000,000	$ 38,000,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR OFFSITE SLUDGE DISPOSAL **$ 11,000,000** **$ 36,000,000**

ESTIMATED INCREMENTAL COST FOR THICKER COVER

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Capping, thick	AC	33	$ 33,000	$ 1,100,000
Capping, thin	AC	210	$ 18,000	$ 3,800,000
Indirect Capital Cost				$ 2,900,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR THICKER COVER **$ 8,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 71,000,000**	**$ 71,000,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 2,600,000**	**$ 30,000,000**	**$ 81,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 101,000,000**	**$ 152,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-15
Results of Laboratory Batch Tests of Reactive Media Using Site Water

Parameter	Units	Well GW-35A				Well MWED-10			
		Initial Concentration	Treated Concentration			Initial Concentration	Treated Concentration		
			Connelly ZVI	Peerless ZVI	ZVI+zeolite		Connelly ZVI	Peerless ZVI	ZVI+zeolite
Aluminum	mg/L	5.14	<0.25	<0.25	<0.25	0.119	<0.25	<0.25	<0.25
Arsenic	mg/L	0.11	<0.03	<0.03	<0.03	0.1	<0.03	<0.03	<0.03
Barium	mg/L	0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02	<0.02
Calcium	mg/L	494.9	438.05	473.79	373.40	795.25	411.76	900.60	602.05
Cobalt	mg/L	0.04	<0.02	<0.02	<0.02	0.004	<0.02	<0.02	<0.02
Copper	mg/L	0.02	<0.02	<0.02	<0.02	<0.011	<0.02	<0.02	<0.02
Iron	mg/L	0.035	0.33	7.50	3.47	0.035	0.31	3.15	0.68
Magnesium	mg/L	314.2	171.19	289.29	271.09	114.4	160.92	131.27	103.73
Manganese	mg/L	38.8	0.09	27.60	18.91	3.358	0.08	3.40	2.26
Nickel	mg/L	0.59	<0.03	<0.03	<0.03	0.0385	<0.03	<0.03	<0.03
Potassium	mg/L	8.18	7.32	7.92	23.48	6.6	6.89	8.07	27.45
Silicon	mg/L	22.2	1.95	2.02	2.78	20.78	1.83	2.34	3.37
Sodium	mg/L	35.45	44.04	53.56	197.08	33.375	41.40	50.95	228.75
Strontium	mg/L	2.07	1.28	1.92	0.83	1.8975	1.21	2.22	1.01
Uranium	ug/L	1879	<0.84	1.93	1.91	80	1.23	1.48	1.29
Zinc	mg/L	1.06	<0.11	<0.11	<0.11	0.0395	<0.11	<0.11	<0.11
pH		4.41	9.24	6.92	6.94	6.32	11.30	7.10	7.23
Reaction Time	hrs	0	96	337	337	0	96	337	337

Notes
All tests used approximately 90 mL solution and 5 g of reactive media (Connelly Iron, Peerless Iron, or 4 g Peerless Iron + 1 g zeolite)
ZVI = zero valent iron
mg/L = milligrams per liter
ug/L = micrograms per liter
Source: Hale (2004)

Table 5-16
Estimated Costs - Alternative 3d

ESTIMATED DIRECT CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Fencing	LF	7,500	$ 37	$ 300,000
Boulder barriers	LF	22,500	$ 2.47	$ 60,000
Regrading	CY	3,800,000	$ 1.64	$ 6,200,000
Consolidation, above grade	CY	1,200,000	$ 1.98	$ 2,400,000
Capping, thick	AC	33	$ 167,000	$ 5,500,000
Capping, thin	AC	210	$ 92,000	$ 19,300,000
Permeable reactive barriers	TON	22,000	$ 880	$ 19,400,000
In-situ pit water treatment (year 1)	Mgal	200	$ 1,700	$ 300,000
Filter press	LS	1	$ 350,000	$ 350,000
Sludge disposal cell	LS	1	$ 1,500,000	$ 1,500,000
Stormwater system	LF	20,000	$ 19	$ 400,000
Biostabilization, MAA sediments	LF	15,000	$ 100	$ 1,500,000
Paving, haul roads	LF	17,100	$ 27	$ 500,000
Unlisted Items	LS		5%	$ 2,900,000
Total Estimated Direct Capital Cost				**$ 61,000,000**

ESTIMATED INDIRECT CAPITAL COSTS

Contingency (30% of direct capital cost)	$ 18,000,000
Non-construction Costs (Engineering, etc) (30% of direct capital cost)	$ 18,000,000
Total Estimated Indirect Capital Cost	**$ 36,000,000**
Total Estimated Capital Cost	**$ 97,000,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Fence maintenance	2% of direct capital cost			1-140	$ 6,000	$ 70,000	$ 200,000
Cover maintenance	1% of direct capital cost			1-140	$ 250,000	$ 3,100,000	$ 8,000,000
PRB media replacement (periodic cost)	LS	1	$ 19,400,000	every 15 yrs	$ 19,400,000	$ 10,000,000	$ 33,000,000
PRB spent media disposal, onsite (periodic cost)	tons	22,000	$ 30	every 15 yrs	$ 660,000	$ 300,000	$ 1,100,000
Open pit amendments reapplication (periodic cost)	Mgal	60	$ 1,700	every 5 years	$ 100,000	$ 200,000	$ 600,000
Treatment system O&M	Mgal/yr	16	$ 8,400	1-140	$ 134,400	$ 1,700,000	$ 4,300,000
Sludge disposal 2005-2007	tons/yr	140	$ 30	1-3	$ 4,200	$ 10,000	$ 10,000
Onsite sludge disposal 2008-2035	tons/yr	50	$ 30	4-140	$ 1,500	$ 10,000	$ 4,000
Onsite sludge disposal cell	2% of direct capital cost			4-140	$ 30,000	$ 290,000	$ 900,000
Treatment system replacement (periodic cost)	LS	1	$ 1,200,000	10, 40, 70, 100, 130	$ 1,200,000	$ 610,000	$ 1,500,000
Biostabilization O&M	5% of direct capital cost			1-140	$ 75,000	$ 930,000	$ 2,400,000
Monitoring	LS	1	$ 245,000	1-140	$ 245,000	$ 3,000,000	$ 7,800,000
Subtotal, O&M costs (annual costs do not include periodic costs)					$ 740,000	$ 20,000,000	$ 60,000,000
Contingency (30%)					$ 220,000	$ 6,000,000	$ 18,000,000
Total Estimated O&M Cost					**$ 1,000,000**	**$ 26,000,000**	**$ 78,000,000**
TOTAL ESTIMATED NET PRESENT WORTH COST						**$ 123,000,000**	**$ 175,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-16 (Continued)
Estimated Costs - Alternative 3d

ESTIMATED INCREMENTAL COST FOR OFFSITE SPENT MEDIA AND SLUDGE DISPOSAL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Sludge Disposal Cell	LS	1	$ (1,500,000)	$ (1,500,000)
Indirect Capital Cost				$ (900,000)
Total Estimated Incremental Capital Cost				$ (2,400,000)

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Spent media disposal (periodic cost)	tons/yr	22,000	$ 580	every 15 yrs	$ 13,000,000	$ 6,000,000	$ 22,000,000
Sludge disposal 2008-2035	tons/yr	50	$ 4,600	4-140	$ 230,000	$ 2,000,000	$ 6,700,000
Contingency (30%)					$ 70,000	$ 2,400,000	$ 8,600,000
Total Estimated Incremental O&M Cost					$ 300,000	$ 10,000,000	$ 37,000,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR OFFSITE SLUDGE DISPOSAL **$ 8,000,000** **$ 35,000,000**

ESTIMATED INCREMENTAL COST FOR THICKER COVER

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Capping, thick	AC	33	$ 33,000	$ 1,100,000
Capping, thin	AC	210	$ 18,000	$ 3,800,000
Indirect Capital Cost				$ 2,900,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR THICKER COVER **$ 8,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 103,000,000**	**$ 103,000,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 1,300,000**	**$ 36,000,000**	**$ 115,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 139,000,000**	**$ 218,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-17
Backfill Volumes and Areas for Open Pits

Backfill Surface Elevation (ft above msl)	Backfill Footprint (acres)	Accumulated Backfill Volume (cy)
Pit 3		
2580	9.3	450,000
2600	11	780,000
2620	13	1,200,000
2640	15	1,600,000
2660	16	2,100,000
2680	18	2,700,000
2700	20	3,300,000
Total Cut Area and Volume	41.7	12,900,000
Pit 4		
3010	2.0	70,000
3020	2.7	100,000
3030	3.5	150,000
3040	4.6	220,000
3050	5.8	300,000
3060 (extrapolated)	7.0	400,000
Total Cut Area and Volume	25.6	3,180,000

Notes:
ft above msl = feet above mean sea level
cy = cy
Sources: Total cut areas and volumes: EPA (2005); other elevations: SMI (2001)

Table 5-18
Estimated Costs - Alternative 4d

ESTIMATED DIRECT CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Fencing	LF	3,800	$ 37	$ 140,000
Boulder barriers	LF	22,500	$ 2.47	$ 60,000
Regrading	CY	2,400,000	$ 1.64	$ 3,900,000
Neutralization Amendment (Lime)	CY	2,700,000	$ 2.40	$ 6,500,000
Organic Material Amendment	CY	2,700,000	$ 5.90	$ 16,000,000
Consolidation, Pit 3	CY	2,400,000	$ 1.98	$ 4,800,000
Consolidation, Pit 4	CY	300,000	$ 1.98	$ 600,000
Capping, thick	AC	19	$ 167,000	$ 3,200,000
Capping, thin	AC	243	$ 92,000	$ 22,000,000
Pit 3 Injection System	LS	1	$ 432,000	$ 430,000
Collection trench	LF	1,650	$ 100	$ 200,000
Expanded water collection system	LS	1	$ 750,000	$ 750,000
Stormwater system	LF	20,000	$ 19	$ 400,000
Excavation, MAA sediments	CY	20,700	$ 20	$ 414,000
Excavation, haul roads	CY	56,000	$ 10.20	$ 600,000
Temporary facilities	LS		5%	$ 3,000,000
Unlisted Items	LS		5%	$ 3,000,000
Total Estimated Direct Capital Cost				**$ 66,000,000**

ESTIMATED INDIRECT CAPITAL COSTS

Contingency (30% of direct capital cost)	$ 20,000,000
Non-construction Costs (Engineering, etc) (30% of direct capital cost)	$ 20,000,000
Total Estimated Indirect Capital Cost	**$ 40,000,000**
Total Estimated Capital Cost	**$ 106,000,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Fence maintenance	2% of direct capital cost			1-140	$ 2,800	$ 30,000	$ 100,000
Cover maintenance	1% of direct capital cost			1-140	$ 250,000	$ 3,100,000	$ 8,000,000
Pumpback system O&M	Mgal/yr	22	$ 650	1-140	$ 14,300	$ 200,000	$ 500,000
Bioreactor monitoring	LS	1	$ 50,000	1-140	$ 50,000	$ 600,000	$ 1,600,000
Injection system O&M	LS	1	$ 67,000	1-140	$ 67,000	$ 800,000	$ 2,100,000
Expanded collection system O&M	5% of direct capital cost			1-140	$ 47,500	$ 590,000	$ 1,500,000
Monitoring	LS	1	$ 245,000	1-140	$ 245,000	$ 3,000,000	$ 7,800,000
Reapplication of amendments	LS	1	$ 1,140,000	30, 60, 90, 120	$ 1,140,000	$ 150,000	$ 700,000
Subtotal, O&M costs (annual costs do not include periodic costs)					$ 680,000	$ 8,000,000	$ 22,000,000
Contingency (30%)					$ 200,000	$ 2,400,000	$ 6,600,000
Total Estimated O&M Cost					**$ 880,000**	**$ 10,000,000**	**$ 29,000,000**
TOTAL ESTIMATED NET PRESENT WORTH COST						**$ 116,000,000**	**$ 135,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-18 (Continued)
Estimated Costs - Alternative 4d

ESTIMATED INCREMENTAL COST FOR WATER TREATMENT AND OFFSITE SLUDGE DISPOSAL

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Treatment system O&M	Mgal/yr	37	$ 8,400	1-140	$ 310,000	$ 3,800,000	$ 9,900,000
Treatment system replacement (periodic cost)	LS	1	$ 1,200,000	10, 40, 70, 100, 130	$ 1,200,000	$ 610,000	$ 1,500,000
Sludge disposal 2005-2007	tons/yr	320	$ 30	1-3	$ 9,600	$ 30,000	$ 30,000
Sludge disposal 2008-2035	tons/yr	110	$ 4,600	4-140	$ 500,000	$ 5,000,000	$ 14,500,000
Contingency (30%)					$ 240,000	$ 3,000,000	$ 8,000,000
Total Estimated Incremental O&M Cost					$ 1,050,000	$ 12,000,000	$ 34,000,000
TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR WATER TREATMENT AND OFFSITE SLUDGE DISPOSAL						**$ 12,000,000**	**$ 34,000,000**

ESTIMATED INCREMENTAL COST FOR THICKER COVER

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Capping, thick	AC	19	$ 33,000	$ 600,000
Capping, thin	AC	243	$ 18,000	$ 4,400,000
Indirect Capital Cost				$ 3,000,000
TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR THICKER COVER				**$ 8,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 114,000,000**	**$ 114,000,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 1,900,000**	**$ 22,000,000**	**$ 63,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 136,000,000**	**$ 177,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-19
Estimated Costs - Alternative 4e

ESTIMATED DIRECT CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Fencing	LF	3,800	$ 37	$ 140,000
Boulder barriers	LF	22,500	$ 2.47	$ 60,000
Regrading	CY	3,300,000	$ 1.64	$ 5,400,000
Consolidation, Pit 3	CY	1,600,000	$ 1.98	$ 3,200,000
Consolidation, Pit 4	CY	220,000	$ 1.98	$ 400,000
Capping, thick	AC	15	$ 167,000	$ 2,500,000
Capping, thin	AC	243	$ 92,000	$ 22,000,000
Soil Cover	AC	26	$ 28,000	$ 730,000
Drainage Blanket, Pit 3	SF	800,000	$ 1.62	$ 1,300,000
Drainage Blanket, Pit 4	SF	240,000	$ 1.62	$ 390,000
Passive Drain, Pit 3	LF	3,500	$ 350	$ 1,200,000
Passive Drain, Pit 4	LF	1,500	$ 350	$ 500,000
Buried pipeline, Pit 4 drain outlet to WTP	LF	2,000	$ 13	$ 26,000
Collection trench	LF	1,650	$ 100	$ 200,000
Expanded water collection system	LS	1	$ 750,000	$ 750,000
Filter press	LS	1	$ 350,000	$ 350,000
Untreated water storage pond	AC	10	$ 140,000	$ 1,400,000
WTP modifications (yearround ops)				Included in unlisted items
Sludge disposal cell	LS	1	$ 1,500,000	$ 1,500,000
Stormwater system	LF	20,000	$ 19	$ 400,000
Excavation, pit sediments	CY	6,400	$ 25	$ 160,000
Excavation, MAA sediments	CY	20,700	$ 20	$ 410,000
Excavation, haul roads	CY	56,000	$ 10.20	$ 600,000
Temporary water control facilities	LS		10%	$ 4,400,000
Unlisted Items	LS		5%	$ 2,200,000
Total Estimated Direct Capital Cost				**$ 50,000,000**

ESTIMATED INDIRECT CAPITAL COSTS

Contingency (30% of direct capital cost)	$ 15,000,000
Non-construction Costs (Engineering, etc) (30% of direct capital cost)	$ 15,000,000
Total Estimated Indirect Capital Cost	**$ 30,000,000**
Total Estimated Capital Cost	**$ 80,000,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Fence maintenance	2% of direct capital cost			1-140	$ 2,800	$ 30,000	$ 100,000
Cover maintenance	1% of direct capital cost			1-140	$ 250,000	$ 3,100,000	$ 8,000,000
Treatment system O&M	Mgal/yr	38	$ 8,400	1-140	$ 320,000	$ 4,000,000	$ 10,200,000
Sludge disposal 2005-2007	tons/yr	670	$ 30	1-3	$ 20,100	$ 50,000	$ 100,000
Onsite sludge disposal 2008-2035	tons/yr	220	$ 30	4-140	$ 6,600	$ 60,000	$ 200,000
Onsite sludge disposal cell maintenance	2% of direct capital cost			4-140	$ 30,000	$ 290,000	$ 900,000
Treatment system replacement (periodic cost)	LS	1	$ 1,200,000	10, 40, 70, 100, 130	$ 1,200,000	$ 610,000	$ 1,500,000
Passive drain maintenance	5% of direct capital cost			1-140	$ 85,000	$ 1,100,000	$ 2,700,000
Expanded collection system O&M	5% of direct capital cost			1-140	$ 47,500	$ 590,000	$ 1,500,000
Monitoring	LS	1	$ 245,000	1-140	$ 245,000	$ 3,000,000	$ 7,800,000
Subtotal, O&M costs (annual costs do not include periodic costs)					$ 990,000	$ 13,000,000	$ 33,000,000
Contingency (30%)					$ 300,000	$ 3,900,000	$ 9,900,000
Total Estimated O&M Cost					**$ 1,300,000**	**$ 17,000,000**	**$ 43,000,000**
TOTAL ESTIMATED NET PRESENT WORTH COST						**$ 97,000,000**	**$ 123,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-19 (Continued)
Estimated Costs - Alternative 4e

ESTIMATED INCREMENTAL COST FOR OFFSITE SLUDGE DISPOSAL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Sludge Disposal Cell	LS	1	$ (1,500,000)	$ (1,500,000)
Indirect Capital Cost				$ (900,000)
Total Estimated Incremental Capital Cost				$ (2,400,000)

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Sludge disposal 2008-2035	tons/yr	220	$ 4,600	4-140	$ 1,000,000	$ 10,000,000	$ 29,000,000
Contingency (30%)					$ 300,000	$ 3,000,000	$ 8,700,000
Total Estimated Incremental O&M Cost					$ 1,300,000	$ 13,000,000	$ 38,000,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR OFFSITE SLUDGE DISPOSAL **$ 11,000,000** **$ 36,000,000**

ESTIMATED INCREMENTAL COST FOR THICKER COVER

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Capping, thick	AC	15	$ 33,000	$ 500,000
Capping, thin	AC	243	$ 18,000	$ 4,400,000
Indirect Capital Cost				$ 2,900,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR THICKER COVER **$ 8,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 86,000,000**	**$ 86,000,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 2,600,000**	**$ 30,000,000**	**$ 81,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 116,000,000**	**$ 167,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-20
Estimated Costs - Alternative 5a

Cost Item	Units	No.	Unit cost	Estimated cost
Regrading	CY	420,000	$ 1.64	$ 700,000
Boulder barriers	LF	10,000	$ 2.47	$ 20,000
Consolidation, Pit 3 & 4	CY	16,700,000	$ 1.98	$ 33,000,000
Capping, thick	AC	0	$ 167,000	$ -
Capping, thin	AC	97	$ 92,000	$ 8,900,000
Soil cover	AC	120	$ 28,000	$ 3,400,000
Drainage Blanket, Pit 3	SF	3,700,000	$ 1.62	$ 6,000,000
Drainage Blanket, Pit 4	SF	2,700,000	$ 1.62	$ 4,400,000
Passive drain, Pit 3	LF	3,500	$ 350	$ 1,200,000
Passive drain, Pit 4	LF	1,500	$ 350	$ 500,000
Passive drains, backfilled pits	LF	2,000	$ 350	$ 700,000
Drain pipe, Pit 4 outlet to WTP	LF	3,000	$ 13	$ 40,000
New water treatment plant	LS	1	$ 1,200,000	$ 1,200,000
Untreated water storage pond	AC	5	$ 140,000	$ 700,000
Filter press	LS	1	$ 350,000	$ 350,000
Sludge disposal cell	LS	1	$ 1,500,000	$ 1,500,000
Stormwater system	LF	6,000	$ 19	$ 110,000
Excavation, pit sediments	CY	6,400	$ 25	$ 160,000
Excavation, MAA sediments	CY	20,700	$ 20	$ 410,000
Excavation, haul roads	CY	56,000	$ 10.20	$ 600,000
Temporary water control measures	LS		10%	$ 6,400,000
Unlisted Items	LS		5%	$ 3,200,000
Total Estimated Direct Capital Cost				**$ 73,000,000**
ESTIMATED INDIRECT CAPITAL COSTS				
Contingency (30% of direct capital cost)				$ 22,000,000
Non-construction Costs (Engineering, etc) (30% of direct capital cost)				$ 22,000,000
Total Estimated Indirect Capital Cost				**$ 44,000,000**
Total Estimated Capital Cost				**$ 117,000,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW (30,7%)	PW (140,3.1%)
Cover maintenance	1% of direct capital cost			1-140	$ 120,000	$ 1,500,000	$ 3,800,000
Treatment system O&M	Mgal/yr	13	$ 8,400	1-140	$ 109,000	$ 1,400,000	$ 3,500,000
Sludge disposal 2005-2007	tons/yr	230	$ 30	1-3	$ 6,900	$ 20,000	$ 20,000
Onsite sludge disposal 2008-2035	tons/yr	80	$ 30	4-140	$ 2,400	$ 20,000	$ 100,000
Onsite sludge disposal cell	2% of direct capital cost			4-140	$ 30,000	$ 290,000	$ 900,000
Treatment system replacement (periodic cost)	LS	1	$ 1,200,000	30, 60, 90, 120	$ 1,200,000	$ 160,000	$ 800,000
Passive drain maintenance	5% of direct capital cost			1-140	$ 120,000	$ 1,500,000	$ 3,800,000
Monitoring	LS	1	$ 245,000	1-140	$ 245,000	$ 3,000,000	$ 7,800,000
Subtotal, O&M costs					$ 630,000	$ 8,000,000	$ 21,000,000
Contingency (30%)					$ 190,000	$ 2,400,000	$ 6,300,000
Total Estimated O&M Cost					**$ 820,000**	**$ 10,000,000**	**$ 27,000,000**
TOTAL ESTIMATED NET PRESENT WORTH COST						**$ 127,000,000**	**$ 144,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-20 (Continued)
Estimated Costs - Alternative 5a

ESTIMATED INCREMENTAL COST FOR OFFSITE SLUDGE DISPOSAL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Sludge Disposal Cell	LS	1	$ (1,500,000)	$ (1,500,000)
Indirect Capital Cost				$ (900,000)
Total Estimated Incremental Capital Cost				$ (2,400,000)

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW(30,7%)	PW (140,3.1%)
Sludge disposal 2008-2035	tons/yr	80	$ 4,600	4-140	$ 370,000	$ 4,000,000	$ 11,000,000
Contingency (30%)					$ 110,000	$ 1,200,000	$ 3,300,000
Total Estimated Incremental O&M Cost					$ 480,000	$ 5,200,000	$ 14,300,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR OFFSITE SLUDGE DISPOSAL **$ 2,800,000** **$ 12,000,000**

ESTIMATED INCREMENTAL COST FOR THICKER COVER

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Capping, thick	AC	-	$ 33,000	$ -
Capping, thin	AC	97	$ 18,000	$ 1,700,000
Indirect Capital Cost				$ 1,020,000

TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR THICKER COVER **$ 3,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 118,000,000**	**$ 118,000,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 1,300,000**	**$ 15,000,000**	**$ 41,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 133,000,000**	**$ 159,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-21
Estimated Costs - Alternative 5c

ESTIMATED DIRECT CAPITAL COSTS

Cost Item	Units	No.		Unit cost		Estimated cost
Regrading	CY	420,000	$	1.64	$	700,000
Consolidation, Pit 3 & 4	CY	18,900,000	$	1.98	$	37,000,000
Boulder barriers	LF	9,000	$	2.47	$	20,000
Excavation, rock	CY	20,000	$	10	$	200,000
Capping, thick (FML + 2.7' soil cover)	AC	80	$	108,000	$	9,000,000
Capping, thin	AC	0	$	92,000	$	-
Soil cover	AC	120	$	28,000	$	3,400,000
Drainage Blanket, Pit 3	SF	3,700,000	$	1.62	$	6,000,000
Drainage Blanket, Pit 4	SF	2,700,000	$	1.62	$	4,400,000
Basal FML liner, Pit 3	SF	560,000	$	1.16	$	650,000
Basal FML liner, Pit 4	SF	70,000	$	1.16	$	80,000
Drainage wells, Pit 3 (4 @ 500 ft)	LF	2,000	$	450	$	900,000
Drainage wells, Pit 4 (4 @ 250 ft)	LF	1,000	$	450	$	450,000
Sludge disposal cell	LS	1	$	1,500,000	$	1,500,000
New water treatment plant	LS	1	$	1,200,000	$	1,200,000
Pipeline to Spokane Arm	LF	36,000	$	13	$	470,000
Untreated water storage pond	AC	5	$	140,000	$	700,000
Filter press	LS	1	$	350,000	$	350,000
Stormwater system	LF	6,000	$	19	$	110,000
Excavation, pit sediments	CY	6,400	$	25	$	160,000
Excavation, MAA sediments	CY	20,700	$	20	$	410,000
Excavation, haul roads	CY	56,000	$	10	$	600,000
Temporary water control measures	LS			10%	$	6,700,000
Unlisted items	LS			5%	$	3,400,000
Total Estimated Direct Capital Cost					**$**	**78,000,000**

ESTIMATED INDIRECT CAPITAL COSTS

Contingency (30% of direct capital cost)	$	23,000,000
Other Indirect Costs (Engineering, etc) (30% of direct capital cost)	$	23,000,000
Total Estimated Indirect Capital Cost	**$**	**46,000,000**
Total Estimated Capital Cost	**$**	**124,000,000**

ESTIMATED OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.		Unit cost	Years[1]		Annual cost		PW(30,7%)		PW (140,3.1%)
Cover maintenance	1% of direct capital cost				1-140	$	120,000	$	1,500,000	$	3,800,000
Drain well O&M	1% of direct capital cost				1-140	$	14,000	$	200,000	$	400,000
Treatment system O&M	Mgal/yr	10	$	8,400	1-140	$	84,000	$	1,000,000	$	2,700,000
Sludge disposal 2005-2007	tons/yr	130	$	30	1-3	$	3,900	$	10,000	$	10,000
Onsite sludge disposal 2008-2035	tons/yr	40	$	30	4-140	$	1,200	$	10,000	$	-
Onsite sludge disposal cell maintainence	2% of direct capital cost				4-140	$	30,000	$	290,000	$	900,000
Treatment system replacement (periodic cost)	LS	1	$	1,200,000	30, 60, 90, 120	$	1,200,000	$	160,000	$	800,000
Pipeline maintenance	2% of direct capital cost				1-140	$	5,000	$	60,000	$	200,000
Monitoring	LS	1	$	245,000	1-140	$	245,000	$	3,000,000	$	7,800,000
Subtotal, O&M costs						$	500,000	$	6,000,000	$	17,000,000
Contingency (30%)						$	150,000	$	1,800,000	$	5,100,000
Total Estimated O&M Cost						**$**	**650,000**	**$**	**8,000,000**	**$**	**22,000,000**
TOTAL ESTIMATED NET PRESENT VALUE COST								**$**	**132,000,000**	**$**	**146,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-21 (Continued)
Estimated Costs - Alternative 5c

ESTIMATED INCREMENTAL COST FOR OFFSITE SLUDGE DISPOSAL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Sludge Disposal Cell	LS	1	$ (1,500,000)	$ (1,500,000)
Indirect Capital Cost				$ (900,000)
Total Estimated Incremental Capital Cost				**$ (2,400,000)**

ESTIMATED INCREMENTAL OPERATIONS AND MAINTENANCE (O&M) COSTS

Cost Item	Units	No.	Unit cost	Years[1]	Annual cost	PW(30,7%)	PW (140,3.1%)
Sludge disposal 2008-2035	tons/yr	40	$ 4,600	4-140	$ 180,000	$ 2,000,000	$ 5,000,000
Contingency (30%)				4-140	$ 50,000	$ 600,000	$ 1,500,000
Total Estimated Incremental O&M Cost					**$ 230,000**	**$ 2,600,000**	**$ 6,500,000**
TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR OFFSITE SLUDGE DISPOSAL						**$ 200,000**	**$ 4,100,000**

ESTIMATED INCREMENTAL COST FOR LONGER COVER MATERIALS HAUL

ESTIMATED INCREMENTAL CAPITAL COSTS

Cost Item	Units	No.	Unit cost	Estimated cost
Capping, thick (FML + 2.7' soil cover)	AC	80	$ 26,000	$ 2,100,000
Indirect Capital Cost				$ 1,300,000
TOTAL ESTIMATED INCREMENTAL PRESENT WORTH COST FOR THICKER COVER				**$ 3,000,000**

COST SUMMARY, INCLUDING INCREMENTAL COSTS

	Annual cost	PW (30,7%)	PW (140,3.1%)
TOTAL ESTIMATED CAPITAL COST INCLUDING INCREMENTAL COSTS		**$ 125,000,000**	**$ 125,000,000**
TOTAL ESTIMATED PRESENT WORTH O&M COST INCLUDING INCREMENTAL COSTS	**$ 900,000**	**$ 11,000,000**	**$ 29,000,000**
TOTAL ESTIMATED PRESENT WORTH COST INCLUDING INCREMENTAL COSTS		**$ 136,000,000**	**$ 154,000,000**

[1] For PW (30,7%) analysis, only costs for first 30 years of O&M are included.

Table 5-22
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Description	Institutional and Access Controls and Ex-Situ Water Treatment	Above-grade Consolidation and Containment of Surface and Stockpiled Materials Expanded and Water Collection and ex-situ Treatment	Above-grade Consolidation and Containment of Surface and Stockpiled Materials and in-situ Treatment of Groundwater (PRBS) and Pit Water	Amendment and Consolidation of Surface and Stockpiled Materials in Pits (Partial Backfill) and Water Treatment in Pit 3 ("Pit Bioreactor")	Consolidation of Surface and Stockpiled Materials in Pits (Partial Backfill) with Pit Drains and ex-situ Water Treatment	Consolidation of Surface and Stockpiled Materials in Open Pits (Complete Backfill) with Pit Drains and ex-situ Water Treatment	Excavation of Backfilled Pits, Consolidation of Surface and Stockpiled Materials in Open Pits (Complete Backfill) with Wells and ex-situ Water Treatment
THRESHOLD CRITERIA							
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT							
Summary Overview	Protective of human health. Not protective of the environment. Longest time to achieve cleanup levels in surface and ground water.	Protective. Longest time to achieve cleanup levels in surface and ground water.	Protective. Similar to 3c.	Protective. Similar to 3c.	Protective. Similar to 3c.	Protective. May achieve cleanup levels in ground water sooner than all alternatives except 5c.	Protective. May achieve cleanup levels in ground water sooner than all other alternatives.
	Water, sediments in open pits will not meet RAOs.	Water, sediments in open pits will not meet RAOs.	Treated water in open pits may not meet RAOs. Pit sediments will not meet RAOs.	Pit water and sediment exposures eliminated. Pit wall exposures possible.	Pit water and sediment exposures eliminated. Pit wall exposures possible.	Pit exposures eliminated.	Pit exposures eliminated.
			Treatability studies required to evaluate PRBs and in-situ water treatment	Treatability studies required to evaluate pit in-situ treatment			

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Protection of Human Health	Access controls reduce risk from exposure to surface materials, radon, and external radiation.	Soil cover reduces risk from exposure to surface materials, radon, and external radiation.	Same as 3c	Same as 3c	Same as 3c	Same as 3c	Same as 3c
	Insititutional and access controls for haul roads and drainage sediments.	Haul roads and drainage sediments contained in place.	Haul roads and drainage sediments contained in place.	Haul roads and drainage sediments contained in pits.	Haul roads and drainage sediments contained in pits.	Haul roads and drainage sediments contained in pits.	Haul roads and drainage sediments contained in pits.
	Permanent land use restrictions required to protect human health *(350 acres)*	Permanent land use restrictions required to protect cover system *(260 acres)*	Permanent land use restrictions required to protect cover system *(260 acres).*	Permanent land use restrictions required to protect cover system *(280 acres).*	Permanent land use restrictions required to protect cover system *(280 acres).*	Permanent land use restrictions required to protect cover system *(97 acres).*	Permanent land use restrictions required to protect cover system *(80 acres).*
	Permanent access restrictions for entire MA	Permanent access restrictions reduce risks to humans from exposure to pit water and sediment.	Permanent access restrictions reduce human exposure to pit water and sediment. Risk from pit water exposure reduced through in situ treatment.	Risk from pit water and sediment exposure eliminated	Risk from pit water and sediment exposure eliminated	Risk from pit water and sediment exposure eliminated	Risk from pit water and sediment exposure eliminated

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	3C	3D	4D	4E	5A	5C
	Surface water and groundwater use restrictions or advisories until RAOs achieved. (foreseeable future)	Surface water and groundwater use restrictions or advisories until RAOs achieved.	Surface water and groundwater use restrictions or advisories until RAOs achieved. (1 to several decades)	Surface water and groundwater use restrictions or advisories until RAOs achieved. (1 to several decades)	Surface water and groundwater use restrictions or advisories until RAOs achieved. (1 to several decades)	Surface water and groundwater use restrictions or advisories until RAOs achieved. (1 to several decades—maybe less than most others)	Surface water and groundwater use restrictions or advisories until RAOs achieved. (1 to several decades – maybe least)
Protection of the Environment	Fence reduces exposure of large animals to pit water and sediment. Barrier not effective for all receptors.	Exposure to pit water and sediment reduced. Barrier not effective for all receptors.	Risks from pit water exposure reduced through in situ treatment.	Risks from pit water and sediment exposure eliminated. High walls remain.	Risks from pit water and sediment exposure eliminated. High walls remain.	All pit exposures eliminated.	All pit exposures eliminated.
	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for the foreseeable future	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for one to several decades (longer than 5a, 5c)	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for one to several decades (longer than 5a, 5c)	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for one to several decades (longer than 5a, 5c)	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for one to several decades (longer than 5a, 5c)	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for one to several decades (5a, 5c may be shorter than others)	Ecological receptors exposed to surface water and sediments in the MAA at levels above background for one to several decades (5a, 5c may be shorter than others)

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
COMPLIANCE WITH POTENTIAL ARARS							
Surface Water *(background for most COCs)*	TWQS would not be met within the foreseeable future.	TWQS met after longer time than 5a and 5c	Same as 3c	Same as 3c	Same as 3c	TWQS met sooner than alternatives other than 5c.	TWQS met soonest.
Groundwater *(background for most COCs)*	350 acre waste management area (WMA).	243 acre waste management area (WMA).	Same as 3c	252 acre WMA.	258 acre WMA.	97 acre WMA.	80 acre WMA.
	Outside of WMA, HSCA would not be met within the foreseeable future.	Outside of WMA, HSCA met after longer time than 5a and 5c	Similar to 3c	Similar to 3c	Similar to 3c.	May meet HSCA outside WMA sooner than most.	May meet HSCA outside WMA soonest.
Soil *(background for most COCs)*	UMTRCA and HSCA would not be met	UMTRCA and HSCA met following construction	Same as 3c	Same as 3c	Same as 3c	Same as 3c	Same as 3c
Sediment *(background for most COCs)*	HSCA would not be met within the foreseeable future.	HSCA met in sediments following MA, MAA controls and recovery period.	Same as 3c	Same as 3c	Same as 3c	Same as 3c	Same as 3c
Radon Flux	UMTRCA would not be met	UMTRCA met following construction	Same as 3c	Same as 3c	Same as 3c	Same as 3c	Same as 3c

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
BALANCING CRITERIA							
LONG-TERM EFFECTIVENESS AND PERMANENCE							
Magnitude of Residual Risk	Potential risks from radiation, air, and soil from cap failure. Requires access restrictions *(350 acres)* and O&M to protect cover integrity.	Potential risks from radiation, air, and soil should cap fail. Requires access restrictions and O&M to protect cover integrity *(260 acres)*.	Same as 3c *(260 acres)*.	Same as 3c, but larger cover area *(280 acres*).	Same as 3c, but larger cover area (*280 acres)*.	Same as 3c, but smaller cover area (97 *acres)*.	Same as 3c, but smallest cover area *(80 acres*).
	Large area of permanent use restrictions in MA.	Large area of permanent use restrictions in MA.	Large area of permanent use restrictions in MA.	Large area of permanent use restrictions in MA.	Large area of permanent use restrictions in MA.	Smaller area of permanent use restrictions in MA.	Smallest area of permanent use restrictions in MA.
	Risks from groundwater in WMA remain. Requires ICs.	Risks from groundwater in WMA remain. Requires ICs.	Same as 3c	Similar to 3c	Similar to 3c	Same as 3c, but smaller WMA	Same as 3c but smallest WMA
	Requires perpetual WTP O&M to prevent further groundwater impacts outside WMA.	Requires perpetual WTP O&M to prevent groundwater impacts outside WMA.	Same as 3c	Same as 3c	Same as 3c	Same as 3c	Same (slight chance of eliminating need for O&M)
	Risks from groundwater outside WMA remain for foreseeable future. Requires ICs for human health.	Risks from groundwater outside WMA remain until cleanup levels achieved. Requires ICs for human health.	Same as 3c	Same as 3c	Same as 3c	Same – may achieve groundwater cleanup levels sooner	Same – may achieve groundwater cleanup levels sooner

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Magnitude of Residual Risk	Outside containment area, risks from surface water and sediment would remain for foreseeable future. ICs for human health don't protect ecological receptors.	Outside containment area, risks from surface water and sediment remain until cleanup levels achieved. ICs for human health would not protect ecological receptors.	Same as 3c	Same as 3c	Same as 3c	Smaller containment area. Cleanup levels may be achieved outside containment area sooner.	Smaller containment area. Cleanup levels may be achieved outside containment area sooner.
	Least effective prevention of ARD.	Less effective prevention of ARD than 5a, 5c	Same as 3c.	Similar to 3c. Reduced ARD generation due to in-situ treatment in Pits 3, 4.	Same as 3c. Reduced ARD generation due to cover over Pits 3, 4.	More effective prevention of ARD except 5c.	Most effective prevention of ARD.
	May not meet cleanup levels in Blue Creek over time.	ARD reduction and active control of groundwater, sediments, & seeps in MAA expected to meet cleanup levels in Blue Creek over time.	ARD reduction and active control of groundwater, sediments, & seeps, in MAA expected to meet cleanup levels in Blue Creek over time.	Greater ARD reduction in MA and active control of groundwater, sediments, & seeps in MAA may accelerate recovery.	Greater ARD reduction in MA and active control of groundwater, sediments, & seeps in MAA may accelerate recovery.	Greatest ARD reduction in MA (except 5c) and active control of sediments in MAA accelerates recovery.	Greatest ARD reduction in MA and Active control of sediments in MAA accelerates recovery.
	Uranium loading to Blue Creek – *Approx. 100 lb/yr* (Under No Action approx. 11,000 lb/yr)	Uranium loading to Blue Creek – *Approx. 21 lb/yr*	*Approx. 28 lb/yr*	*Approx. 33 lb/yr*	*Approx. 21 lb/yr*	*Approx. 25 lb/yr* (no groundwater interception downgradient of WMA)	*Approx. 29 lb/yr* (no groundwater interception downgradient of WMA)

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Adequacy and Reliability of Controls	Existing cover may need more maintenance due to steeper slopes	Reliability of soil cover good if maintained.	Same as 3c	Same – larger cover area.	Same – larger cover area.	Same – smaller cover area	Same – smallest cover area
	Easy to control pit water level with O&M of pumps.	Easy to control pit water level with O&M of pumps.	PRBs and pit water treatment less reliable than ex-situ treatment. Easy to control pit water level with O&M of pumps.	Pit bioreactor amendments require periodic replacement. Less reliable, may be difficult to control.	Risk of poor groundwater quality if water accumulates in pits. Maintenance of drainage system is critical. Can use wells if drains fail.	Risk of poor groundwater quality if water accumulates in pits. Maintenance of drainage system is critical. Can use wells if drains fail.	Risk of poor groundwater quality if water accumulates in pits. Maintenance of pumps is critical.
	Contaminants remain on site above health based levels. ICs are limited in effectiveness due to enforceability.	Contaminants remain on site above health based levels. ICs are limited in effectiveness due to enforceability.	Same as 3c	Same as 3c	Same as 3c	Same as 3c – but smaller area, may be shorter duration	Same as 3c – but smaller area, may be shorter duration
	Groundwater and surface water collection and ex-situ treatment reliable if maintained.	Same as 2b	PRB reliability good if well designed, maintained.	Reliability of pit bioreactors less certain than ex-situ treatment	Same as 2b	Same as 2b	Same as 2b

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	3C	3D	4D	4E	5A	5C
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT							
Treatment Process Used	Lime precipitation in WTP.	Same as 2b	PRBs using ZVI for water outside MA , lime in open pits Lime precipitation in WTP, if needed	Addition of lime and organic material with backfill in Pits 3 & 4 Lime precipitation in WTP, if needed	Same as 2b	Same as 2b	Same as 2b
Amount Destroyed or Treated	Most ARD treated (because most generated)	More ARD treated (because more generated than 5a and 5c)	Same as 3c	Same as 3c	Same as 3c	Least ARD treated (because least generated except 5c)	Least ARD treated (because least generated)
Reduction of TMV	Reduced toxicity of water through ex situ treatment.	Reduced volume and toxicity of contaminated groundwater through ex situ treatment. Treatment supplements ARD reduction.	Same, plus pit water treatment and PRBs.	Same as 3c, plus pit bioreactor	Same as 3c	Same as 3c	Same as 3c
Irreversible Treatment	WTP irreversible	WTP irreversible	WTP irreversible. Precipitates from pit water treatment could be remobilized to pit water due to chemistry changes.	WTP irreversible. Pit bioreactor chemistry changes could remobilize contaminants.	WTP irreversible	WTP irreversible	WTP irreversible

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Type and Quantity of Residuals Remaining After Treatment	Estimated sludge volume = 12,000 cf/yr, dewatered	Estimated sludge volume = 5,800 cf/yr, dewatered	Estimated sludge volume = 1,300 cf/yr, dewatered Residuals disposal when PRBs replaced (~15 yrs)	Estimated sludge volume = 2,900 cf/yr, dewatered	Estimated sludge volume = 5,800 cf/yr, dewatered	Estimated sludge volume = 2,100 cf/yr, dewatered	Estimated sludge volume = 1,000 cf/yr, dewatered
SHORT TERM EFFECTIVENESS							
Community Protection	No hauling of clean borrow material	Hauling clean borrow material may adversely affect community (1 – 2 million cubic yds)	Same as 3c	Same as 3c	Same as 3c	Less clean borrow material to be hauled (500,000-800,000 cubic yds)	Less clean borrow material to be hauled (400,000 cubic yds)
	Hauling of treatment residuals may affect community *(~ 12,000 cf/yr).*	Hauling of treatment residuals may affect community *(~ 5,800 cf/yr).*	Hauling of treatment residuals may affect community *(~1,300 cf/yr).*	Hauling of treatment residuals may affect community *(~2,900 cf/yr).*	Hauling of treatment residuals may affect community *(~5,800 cf/yr).*	Hauling of treatment residuals may affect community *(~2,100 cf/yr).*	Hauling of treatment residuals may affect community *(~1,000 cf/yr).*
Worker Protection	Shortest construction time and no mine waste earthwork	Shorter construction time and less mine waste earthwork *(~5,000,000 cy).*	Shorter construction time and less mine waste earthwork. *(~5,000,000 cy).*	Medium construction time and less mine waste earthwork. *(~5,000,000 cy).*	Longer construction time and more mine waste earthwork *(~5,000,000 cy).*	Longer construction time and more mine waste earthwork. *(~17,000,000 cy).*	Longest construction time and most mine waste earthwork. *(~19,000,000 cy).*
	Potential worker exposure in WTP and sludge management *(~ 80 Mgal/yr).*	Potential worker exposure in WTP and sludge management (~38 Mgal/yr).	Potential worker exposure in WTP and sludge management (~16 Mgal/yr). PRB periodic replacement may impact workers	Potential worker exposure in WTP and sludge management (up to ~37 Mgal/yr).	Potential worker exposure in WTP and sludge management. (~38 Mgal/yr).	Potential worker exposure in WTP and sludge management (~13 Mgal/yr).	Potential worker exposure in WTP and sludge management (~10 Mgal/yr).

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Environmental Impacts	MA construction period shortest, no impacts from dust, short term ARD increases, sediment. No impacts to sediment in MAA	MA construction period shortest, least movement of waste – fewer impacts from dust, short term ARD increases, sediment More impacts at borrow area, because larger borrow volume.	MA construction period and impacts same as 3c.	MA construction period longer, more movement of waste than 3c, 3d	Same as 4d	MA construction period longer than all but 5c. Significant movement of waste, less borrow material than 3c, 3d, 4d, 4e	MA construction period longer than all others. Most movement of waste, least borrow material.
		In situ sediment controls in MAA least impact.	Same as 3c.	MAA sediment removal greater impact.	Same as 4d.	Same as 4d.	Same as 4d.
	No construction impacts for MAA groundwater	Minor construction impacts for MAA groundwater capture, if needed	PRBs in MAA may have impacts during construction and replacement.	Same as 3c	Minor construction impacts for MAA groundwater capture, if needed	No groundwater capture in MAA.	No groundwater capture in MAA.
Time until Action is Complete	Less than 1 year to construct	2-3 years to construct	2-3 years to construct	4-5 years to construct	4-5 years to construct	6-8 years to construct	7-9 years to construct
IMPLEMENTABILITY							
Ability to Construct and Operate	Standard engineering.	Standard engineering.	Standard engineering.	Standard engineering.	Mostly standard engineering.	Standard engineering.	Standard engineering.
			PRB may pose construction challenge.	Backfill alternatives require phasing and water management.	Same as 4d	Similar as 4d, with longer construction time	Similar to 4d, with longer construction time. Uncertain capacity for materials excavated from existing backfilled pits.

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Ease of Taking More Action if Needed	Additional groundwater remedial work could be done downgradient of MA if needed.	Additional groundwater remedial work could be done downgradient of MA if needed.	Additional groundwater remedial work could be done downgradient of MA if needed.	Additional groundwater remedial work could be done downgradient of MA if needed.	Additional groundwater remedial work could be done downgradient of MA if needed.	Additional groundwater remedial work could be done downgradient of MA if needed.	Additional groundwater remedial work could be done downgradient of MA if needed.
Ability to Monitor Effectiveness	Easy to monitor surface and subsurface conditions.	Easy to monitor surface and subsurface conditions.	Easy to monitor surface and subsurface conditions. PRB requires careful monitoring.	Easy to monitor surface and subsurface conditions. Treatment in pits may be difficult to assess.	Easy to monitor surface and subsurface conditions.	Easy to monitor surface and subsurface conditions.	Easy to monitor surface and subsurface conditions.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with Tribe, USFWS, BIA, BLM, DOH.	Same as 2b	Same as 2b PRBs would require additional Tribal cultural oversight, FWS involvement.	Same as 2b	Same as 2b	Same as 2b	Same as 2b

Table 5-22 (Continued)
Summary of Comparative Analysis

Criterion	Alternative[1]						
	2B	**3C**	**3D**	**4D**	**4E**	**5A**	**5C**
Availability of Equipment, Specialists, and Materials	Available	Borrow materials exist within 45 miles for all alternatives, but sources not currently developed	Same as 3c	Same as 3c	Same as 3c	Same as 3c	Same as 3c
			PRB materials may be difficult to obtain.	Availability of pit bioreactor amendments may be an issue.	Directional drilling requires qualified contractor.	Directional drilling requires qualified contractor.	
Availability of Technologies	Available	Available	Available	Available	Available	Available	Available
COST							
Base costs[18]							
Present Worth 30 year, 7%	$22M	$82M	$123M	$116M	$97M	$127M	$132M
140 year, 3.1%	$49M	$108M	$175M	$135M	$123M	$144M	$146M
Base + incremental[19]							
Present Worth 30 year, 7%	$44M	$101M	$139M	$136M	$116M	$133M	$136M
140 year, 3.1%	$118M	$152M	$218M	$177M	$167M	$159M	$154M

Note:
[1] Alternative 1 (No Action) is not protective and is not included in the summary table. See text for details
Base costs assume on-site sludge disposal and the low end of the cost range for borrow material.
Base + incremental costs assume off-site sludge disposal and the high end of the cost range for borrow material.

Table 5-23
Estimated Post-Remedy Water Treatment and Sludge Generation Quantities

Alternative	Estimated Average Annual Treatment (gallons per year)	Estimated Dewatered Sludge Produced (tons per year)
2b	80,000,000	470
3c	38,000,000	220
3d[1]	Pit lakes: 16,000,000 PRBs: 22,000,000	0 to 50 tons of sludge per year 25,000 tons of spent media every 15 years
4d[1]	Pit bioreactors: 37,000,000	0 to 110
4e	38,000,000	220
5a	13,000,000	80
5c	10,000,000	40

Notes
[1]Lower bound of sludge produced assumes no additional treatment of Pit 3 and Pit 4 water required after in-situ treatment; upper bound assumes additional treatment of Pit 3 and Pit 4 water required after in-situ treatment.

Table 5-24
Summary of Estimated Present Worth Costs

Alternative	Scenario	Capital Cost ($)	Annual O&M Cost ($)	PW(30,7%) ($)	PW(140,3.1%) ($)
2b	Base	4,800,000	1,300,000	22,000,000	49,000,000
	Base + incremental	2,400,000	3,800,000	44,000,000	118,000,000
3c	Base	65,000,000	1,300,000	82,000,000	108,000,000
	Base + incremental	71,000,000	2,600,000	101,000,000	152,000,000
3d	Base	97,000,000	1,000,000	123,000,000	175,000,000
	Base + incremental	103,000,000	1,300,000	139,000,000	218,000,000
4d	Base	106,000,000	880,000	116,000,000	135,000,000
	Base + incremental	114,000,000	1,900,000	136,000,000	177,000,000
4e	Base	80,000,000	1,300,000	97,000,000	123,000,000
	Base + incremental	86,000,000	2,600,000	116,000,000	167,000,000
5a	Base	117,000,000	820,000	127,000,000	144,000,000
	Base + incremental	118,000,000	1,300,000	133,000,000	159,000,000
5c	Base	124,000,000	650,000	132,000,000	146,000,000
	Base + incremental	125,000,000	900,000	136,000,000	154,000,000

Notes
1. Alternatives 2b, 3c, 3d, and 4e include a periodic cost of $1,600,000 (including contingency) for replacement of the WTP in year 10 and every 30 years thereafter.
2. Alternative 3d includes periodic costs of $26,000,000 to $42,000,000 (including contingency) for replacement of the spent reactive media in year 15 and every 15 years thereafter and $130,000 (including contingency) for reapplication of pit lake amendments in year 5 and every 5 years thereafter
3. Alternative 4d includes a periodic cost of $1,500,000 (including contingency) for reapplication of bioreactor amendments in year 30 and every 30 years thereafter
4. Alternatives 5a and 5c include a periodic cost of $1,200,000 for replacement of the WTP in year 30 and every 30 years thereafter.

Table 5-25
Ranking of Alternatives Based on Cost

Cost Scenario	Ranking of Alternatives, Lowest Cost (1) to Highest Cost (7)						
	1	2	3	4	5	6	7
Base Costs 30 yrs, 7%	2b ($22M)	3c ($82M)	4e ($97M)	4d ($116M)	3d ($123M)	5a ($127M)	5c ($132M)
Base + Incremental Costs 30 yrs, 7%	2b ($44M)	3c ($101M)	4e ($116M)	5a ($133M)	4d & 5c ($136M)	—	3d ($139)
Base Costs 140 yrs, 3.1%	2b ($49M)	3c ($108M)	4e ($123M)	4d ($135M)	5a ($144M)	5c ($146M)	3d ($175M)
Base + Incremental Costs 140 yrs, 3.1%	2b ($118M)	3c ($152M)	5c ($154M)	5a ($159M)	4e ($167M)	4d ($177M)	3d ($218M)

Table 5-26
Comparison of Onsite and Offsite Disposal Using CERCLA Criteria

Criterion	Onsite Sludge Disposal	Offsite Sludge Disposal
Overall Protection of Human Health and the Environment	Protective covers and institutional controls used to protect human health. Protective cover used to protect ecological receptors. Sludge solidification, cover, and liner system would limit transport of COCs in air, surface water, and groundwater to very low levels. Could locate within footprint of waste rock containment areas and avoid expanding area of groundwater impacts.	Protective onsite due to removal of sludge from site. Offsite disposal facility includes engineering and institutional controls to provide protection. Risks from sludge transport would be limited using health and safety practices.
Compliance with ARARs	Siting of disposal area would have to comply with HSCA and applicable NRC regulations. (Disposal within footprint of backfilled pits under Alts 4e, 5a, and 5c may comply). Design would comply with RCRA Subtitle D and C requirements determined to be relevant and appropriate.	Offsite actions would comply with ARARs and TBCs. Offsite transport and disposal would be in compliance with applicable laws.
Long-Term Effectiveness and Permanence	Risks from radon and external radiation exposures reduced to acceptable levels using access restrictions and daily cover in active areas. Protective cover and access and use restrictions for longer-term protection for closed cells. Residual risks further reduced by sludge solidification. Estimated area affected by 100 years of disposal = 1 to 3 acres (varies depending on alternative). Institutional controls would need long-term enforcement and maintenance. Protective cover would require some level of maintenance (depending on design). Due to solidification, residual risks would be less than current sludge should ICs fail.	No residual risks on site. Long-term risk to community due to sludge hauling an estimated 1,800 to 12,000 cubic feet (about 7 to 45 truck trips) of sludge per year (varies depending on alternative). Risks have not been quantified. Solidification of sludge would reduce residual risks should release occur during transport. Offsite disposal facility would maintain engineering and institutional controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	All sludge would be solidified, which would reduce mobility of contaminants in sludge relative to current sludge characteristics.	Same as onsite disposal; all sludge solidified

Table 5-26 (Continued)
Comparison of Onsite and Offsite Disposal Using CERCLA Criteria

Criterion	Onsite Sludge Disposal	Offsite Sludge Disposal
Short-Term Effectiveness	Limited impacts to community from hauling materials to site for construction of disposal area. 1 to 2 years needed to design and construct onsite facility. If construction is not complete by time the Ford facility closes, disposal at Richland facility could be implemented until onsite facility is ready.	No impacts to community from hauling construction materials for disposal materials. No construction time. Would need to design and implement process for onsite dewatering and solidification.
Implementability	Construction of disposal area is technically feasible. Significant administrative implementability issues with Tribe and, potentially, other affected landowners. Would need to work with Tribe and BIA on institutional controls for land (if outside mine waste containment areas). Would need additional disposal capacity beyond 100 years, unless no further water treatment was needed.	Would need to be dewatered and/or treated to eliminate free liquids prior to disposal, which would be technically implementable. Would need approval from Interstate Compact to dispose of sludge out-of-state if U-238 limit eliminates possibility of disposal at Richland facility. Facility in Utah likely to be available. Richland facility has volume capacity until at least 2056. No guarantees of capacity at any site in the more distant future.
Cost (1)	Estimated capital cost for construction of onsite disposal disposal = $2.4 million. Estimated disposal cost = $5/cf	No capital cost Estimated cost for disposal at Richland facility as low-level radioactive waste = $160/cf - $200/cf

Notes
1. Costs for additional sludge dewatering and solidification are not included; the requirements are the same for both onsite and offsite sludge disposal and are addressed in the cost estimates for water treatment. Onsite facility estimate assumes RCRA Subtitle C design.

Table 5-27
Summary of Estimated Water Treatment Costs

Treatment Train	Direct Capital	O&M, $/kgal ($)	O&M, Alt 5c, $/kgal ($)	30-year, 7% present worth cost				140-year, 3.1% present worth cost (30 year replacement)			
				Alt 2b (80 Mgal/yr)	Alts 3c, 4e (38 Mgal/yr)	Alt 5a (13 Mgal/yr)	Alt 5c (10 Mgal/yr)	Alt 2b (80 Mgal/yr)	Alts 3c, 4e (38 Mgal/yr)	Alt 5a (13 Mgal/yr)	Alt 5c (10 Mgal/yr)
Options that do not remove sulfate											
Lime precipitation + offsite sludge disposal (Richland)	$875,000	$36.00	$29.20	$37,000,000	$20,000,000	$8,000,000	$5,000,000	$104,000,000	$55,000,000	$20,000,000	$13,000,000
IX + Lime precipitation + offsite sludge disposal (Grandview)	$2,475,000	$19.80	$17.90	$29,000,000	$16,000,000	$8,000,000	$7,000,000	$72,000,000	$38,000,000	$17,000,000	$14,000,000
Options that remove sulfate											
IX + Lime precipitation + Grandview + NF + Evap pond + Graham Rd	$7,000,000	$25.30	$23.00	$44,000,000	$27,000,000	$17,000,000	$15,000,000	$102,000,000	$58,000,000	$32,000,000	$28,000,000
IX + Lime precipitation + Grandview + NF + Mech evap/crystalization + Graham Rd	$9,200,000	$32.30	$30.00	$56,000,000	$35,000,000	$21,000,000	$20,000,000	$131,000,000	$75,000,000	$42,000,000	$37,000,000

Notes
Total costs for water treatment include 60% indirect capital costs and 30% contingency on operating costs
For lime precipitation + offsite sludge disposal (Richland) under Alternative 2b, used unit cost of $33/kgal.
For 140 year, 3.1% present worth analysis, periodic costs equal to the direct capital cost are included at years 30, 60, 90, and 120.
The unit cost for disposal of residuals is 25% lower under Alternative 5c because of a lower unit residuals production rate.
kgal = 1,000 gallons; Mgal = 1,000,000 gallons

Treatment Train	Description
Lime precipitation + offsite sludge disposal (Richland	Existing chemical precipitation system with onsite disposal of dewatered sludge (years 1-3) and offsite disposal of dewatered sludge at U.S. Ecolo Richland, WA facility (year 4 to end)
IX + Lime precipitation + offsite sludge disposal (Grandview)	(1) Uranium removal using ion exchange with resin regeneration at mill in Colorado; (2) existing chemical precipitation system with disposal of dewatered sludge at U.S. Ecology Grandview, Idaho facility
IX + Lime precipitation + Grandview + NF + Evap pc + Graham Rd	(1) Uranium removal using ion exchange with resin regeneration at mill in Colorado; (2) existing chemical precipitation system with disposal of dewatered sludge at U.S. Ecology Grandview, Idaho facility; (3) nanofiltration to remove sulfate with disposal of reject water in onsite evaporatior pond and disposal of salts at Waste Management Graham Road facility
IX + Lime precipitation + Grandview + NF + Mech evap/crystalization + Graham Rd	(1) Uranium removal using ion exchange with resin regeneration at mill in Colorado; (2) existing chemical precipitation system with disposal of dewatered sludge at U.S. Ecology Grandview, Idaho facility; (3) nanofiltration to remove sulfate; (4) mechanical evaporation and crystallization to evaporate NF reject; and (5) disposal of salt cake at Waste Management Graham Road facility

Table 5-28
Summary of Estimated Total Costs including Various Water Treatment and Disposal Options

Scenario	Alternative 2b		Alternative 3c		Alternative 4e		Alternative 5a		Alternative 5c	
	30,7%	**140,3.1%**	**30,7%**	**140,3.1%**	**30,7%**	**140,3.1%**	**30,7%**	**140,3.1%**	**30,7%**	**140,3.1%**
Total present worth cost not including water treatment and disposal (Note 1)	$7,000,000	$14,000,000	$81,000,000	$97,000,000	$96,000,000	$112,000,000	$125,000,000	$138,000,000	$131,000,000	$142,000,000
Total present worth cost including water treatment										
Options that do not remove sulfate										
Lime precipitation + offsite sludge disposal (Richland)	$44,000,000	$118,000,000	$101,000,000	$152,000,000	$116,000,000	$167,000,000	$133,000,000	$158,000,000	$136,000,000	$155,000,000
IX + Lime precipitation + offsite sludge disposal (Grandview)	$36,000,000	$86,000,000	$97,000,000	$135,000,000	$112,000,000	$150,000,000	$133,000,000	$155,000,000	$138,000,000	$156,000,000
Options that remove sulfate										
IX + Lime precipitation + Grandview + NF+ Evap pond +Graham Rd	$51,000,000	$116,000,000	$108,000,000	$155,000,000	$123,000,000	$170,000,000	$142,000,000	$170,000,000	$146,000,000	$170,000,000
IX + Lime precipitation + Grandview + NF + Mech evap/crystalization + Graham Rd	$63,000,000	$145,000,000	$116,000,000	$172,000,000	$131,000,000	$187,000,000	$146,000,000	$180,000,000	$151,000,000	$179,000,000

Notes
1. Includes thicker cover costs

Treatment Train	Description
Lime precipitation + offsite sludge disposal (Richland)	Existing chemical precipitation system with onsite disposal of dewatered sludge (years 1-3) and offsite disposal of dewatered sludge at U.S. Ecology Richland, WA facility (year 4 to end)
IX + Lime precipitation + offsite sludge disposal (Grandview)	(1) Uranium removal using ion exchange with resin regeneration at mill in Colorado; (2) existing chemical precipitation system with disposal dewatered sludge at U.S. Ecology Grandview, Idaho facility
IX + Lime precipitation + Grandview + NF+ Ev pond +Graham Rd	(1) Uranium removal using ion exchange with resin regeneration at mill in Colorado; (2) existing chemical precipitation system with disposal dewatered sludge at U.S. Ecology Grandview, Idaho facility; (3) nanofiltration to remove sulfate with disposal of reject water in onsite evapor pond and disposal of salts at Waste Management Graham Road facility
IX + Lime precipitation + Grandview + NF + M evap/crystalization + Graham Rd	(1) Uranium removal using ion exchange with resin regeneration at mill in Colorado; (2) existing chemical precipitation system with disposal dewatered sludge at U.S. Ecology Grandview, Idaho facility; (3) nanofiltration to remove sulfate; (4) mechanical evaporation and crystallizatio evaporate NF reject; and (5) disposal of salt cake at Waste Management Graham Road facility

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