Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
No Action	None	None	No action would be taken and operation of the existing water treatment plant (WTP) would cease. The contaminated area would remain in its existing condition or worsen overtime.	Not Applicable (NA) Consideration required by the NCP.	NA Consideration required by the NCP.	No Cost
No Further Action	None	None	No new action would be taken; however the existing WTP would continue to operate without significant upgrades or repairs.	The existing collection and treatment system is effective at capturing some groundwater, which enters Pit 3 and Pit 4. However, concentrations of contaminants of concern (COCs) in groundwater are not reduced.	Existing WTP may be approaching end of its practical life cycle.	Low Capital Medium O&M
Institutional Controls	Land Use Controls	Deed/Zoning Restrictions	Groundwater use would be restricted through legally binding requirements on property such as deed and zoning restrictions. Restrictions would be used to prevent use or transfer of property without notification of limitations on the use of the property.	Potentially effective in preventing human contact with contaminated groundwater, but would not reduce loadings of COCs from groundwater to surface water.	Legal requirements which are readily implemented.	Low Capital Low O&M
	Access Restrictions	Physical Restrictions (Posted Warnings and Well Security)	Warning signs would be posted to control access, and onsite wells would be secured. Monitoring would be performed to ensure controls remain in place.	Potentially effective in limiting direct exposure to humans with contaminated media. Long term effectiveness depends on future implementation/O&M. Would not protect the environment.	Readily Implemented.	Low Capital Low O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Institutional Controls (continued)	Community Awareness	Information and Educational Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies.	Potentially effective in preventing human contact with contaminated groundwater.	Readily Implemented.	Low Capital Low O&M
Monitoring	None	Long-term Groundwater Monitoring	Periodic monitoring for COCs in groundwater.	Effective in documenting groundwater quality, but does not reduce human exposure to contaminated groundwater.	Readily Implemented.	Low Capital Medium O&M
		Monitored Natural Attenuation	Contaminated groundwater would be allowed to equilibrate through natural in-situ processes such as dilution, adsorption, and chemical reactions with subsurface materials present in the aquifer. Monitoring would be done to demonstrate reductions in contaminant concentrations.	Limited effectiveness for inorganics and radionuclides. However, some reduction in COC loadings may occur with source depletion/control, natural adsorption and flushing processes. Monitoring would be necessary to evaluate effectiveness.	Readily Implemented.	Medium Capital Medium O&M
Containment	Physical Barriers	Shallow Diversion {NOT RETAINED}	Shallow physical barriers (slurry walls, grout curtains, or sheet pile walls) would be constructed to isolate contaminated groundwater from shallow zone media such as sediment and surface water.	May be an effective barrier to subsurface flow at some locations but not effective at some locations because of the complex 3D-flow system in the extremely heterogeneous fractured rock and lack of confining layer.	Difficult to install with subsurface conditions present at the site.	High Capital Low O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Containment (continued)	Physical Barriers (continued)	Compacted Soil/Clay Barrier	A layer of low permeability compacted fill would be installed to prevent migration of groundwater through contaminated source material thereby reducing contaminant migration to groundwater.	May be an effective barrier for some locations.	May be difficult to find a nearby source of clay and soil.	Medium Capital Low O&M
		Synthetic Barrier {NOT RETAINED}	Synthetic material would be installed around or under contaminated media to divert groundwater away from contaminated media and reduce contaminant migration to groundwater.	May be an effective barrier for some locations, but not effective at some locations because of the complex 3D-flow system in the extremely heterogeneous fractured rock and lack of confining layer. The longevity of synthetics are uncertain.	Difficult to install with subsurface conditions present at the site.	Medium Capital Low O&M
Removal	Passive Removal / Drainage	Gravity Drain	Should Pit 3 or Pit 4 be filled solid materials, groundwater would be limited to a specific elevation using a gravity drainage system and routed to a treatment plant for processing. Only considered for Pit 3 and Pit 4.	Potentially effective at reducing loadings of COCs from groundwater to surface water. May be susceptible to plugging from precipitates.	Depending on the water level desired a gravity drain may be difficult to design and construct with the site topography.	High Capital Low O&M
	Active Removal / Hydraulic Barrier	Groundwater Extraction Trench	Groundwater would be removed from trenches and treated. Trenches would be installed across the groundwater flow path to limit migration of the COCs.	May be an effective collection mechanism for locations with shallow groundwater.	Not practical for extreme depths. Shoring and dewatering would likely be required for installation.	Medium Capital Medium O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Removal (continued)	Active Removal / Hydraulic Barrier (continued)	Groundwater Extraction Wells	Groundwater would be removed using extraction wells and treated. The wells would be pumped to create a capture zone for the groundwater and reduce further migration.	May be an effective collection mechanism for some locations. However, not as effective as interceptor trench for capturing shallow groundwater. May be susceptible to plugging from precipitates.	Readily Implemented.	Medium Capital Medium O&M
Treatment	Continue Operating Existing WTP [a]	Chemical Precipitation	Active water treatment continues using the existing WTP without modification. Sludge generated during treatment would continue to be disposed off-site at the Ford Mill until closure or at a new disposal site.	Effective in the removal and treatment of surface water and some groundwater with metals and radionuclides, but does not reduce concentrations of COCs in groundwater. WTP effluent has high levels of SO_4.	Proven technology currently being used at the site. Existing WTP may be approaching end of its practical life cycle.	Low Capital Medium O&M
	Ex-Situ Physical/Chemical [a]	Aeration / Air Stripping {NOT RETAINED}	Injection of air into the contaminated water forming bubbles that transfer dissolved COCs to the air phase for collection and/or treatment.	Effective for removing radon from water, but not other COCs. Potential fouling problems.	May have difficulty meeting substantive permit requirements.	Low Capital Low O&M
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Regeneration of resins results in concentrated brine that would need additional treatment and/or disposal.	Very effective in reducing concentrations and removing metals and radionuclides.	May need more than one type of resin for different radionuclides. Conventional proven technology, readily available equipment.	High Capital Medium O&M

EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER

Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Treatment (continued)	Ex-Situ Physical/Chemical [a] *Precipitation*	Neutralization/ Precipitation	Adjustment of pH after soluble metal salts are converted to insoluble salts that would precipitate. Typically performed with lime, limestone, or sodium hydroxide but the use of other alkalis is technically feasible. Precipitants would be removed from solution by settling.	Effective in increasing pH and precipitation of inorganics, but not as effective for radionuclides as chemical precipitation with coagulation/flocculation.	Readily Implemented.	Low Capital Low O&M
		Chemical Precipitation with Coagulation/ Flocculation	Addition of chemicals such as lime or caustic soda to raise the pH and form insoluble inorganic species. Coagulation and flocculation processes would be used to increase particle size for removal from solution. Technology is currently being used at the site, but would likely be modified to improve performance and reduce sludge generation. Residual from the treatment is sludge.	Effective in reducing concentrations of metals and radionuclides. However, not as effective as the high density sludge (HDS) process presented below.	Readily Implemented. Conventional proven technology, equipment readily available.	Medium Capital Medium O&M
		High Density Sludge (HDS)	Chemical precipitation process that produces a high density sludge (increased solids content) thereby reducing the volume of sludge needing additional treatment and/or disposal.	Very effective in reducing concentrations of metals and radionuclides.	Conventional proven technology, equipment readily available.	High Capital Medium O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS
FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Treatment (continued)	Ex-Situ Physical/Chemical [a] *Precipitation* (continued)	GECO HDS Process {NOT RETAINED}	A variant to the conventional HDS process; GECO uses a two step neutralization process producing a high density sludge. Recycled sludge is contacted with contaminated water in first reactor and lime slurry is added in second reactor.	Innovative technology similar to HDS that would require treatability testing.	Variation to HDS process that has only been used at a few small scale sites.	Medium Capital Medium O&M
		Silica Micro Encapsulation/ KEECO Process {NOT RETAINED}	A process similar to chemical precipitation. Chemical added to the contaminated media initiates a reaction process that involves precipitation and hydroxyl formation and an electrokinetic reaction. Silica components form a tight matrix around metals and produce more stable sludge that reduces leaching of COCs.	Effectiveness similar to chemical precipitation. Innovative technology that would require treatability testing to determine effectiveness.	Proprietary chemical available from one supplier.	Medium Capital Medium O&M
		Dicalcium Silicate Process (Di-Cal) {NOT RETAINED}	Neutralization and precipitation process using Ca_2SiO_4 that produces fast filtering and more stable precipitates.	Innovative technology similar to HDS that would require treatability testing.	Innovative technology. Di-Cal may not be as readily available as lime	High Capital Medium O&M
		Self Assembled Monolayers on Mesoporous Supports (SAMMS) {NOT RETAINED}	Contaminated water contacts a mesoporous ceramic. The specialized molecules bind heavy metal ions to the surface of the ceramic substrate, which has porous structure that provides a huge surface area.	Innovative technology that would require treatability testing to determine effectiveness.	Innovative technology, not demonstrated at full scale	High Capital Medium O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS
FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Treatment (continued)	Ex-Situ Physical/Chemical [a] *Separation*	Ultrafiltration/ Microfiltration {NOT RETAINED}	Ultrafiltration / microfiltration occurs when particles are separated by forcing fluid through a semipermeable membrane. Only the particles whose size are smaller than the openings of the membrane are allowed to flow through.	Effective in removing metals and radionuclides from solution.	Complex system.	High Capital Medium O&M
		Tri-Media Filter	A tri-media filter consists of three layers of natural materials such as anthracite coal, silica sand, and crushed garnet sand.	Effective in removing suspended solids from water. Proven technology.	Readily Implemented.	Medium Capital Medium O&M
		Reverse Osmosis	Contaminated water is passed through a semipermeable membrane at high pressure leaving a concentrated residual behind as membrane rejection.	Effective in removing metals and radionuclides from solution. Historical attempts to use reverse osmosis at the site resulted in O&M problems associated with precipitation of gypsum.	Readily available equipment.	Medium Capital Medium O&M
		Ceramic Microfiltration Technology {NOT RETAINED}	Liquid/solid separation process using advanced ceramic microfiltration membranes. Follows initial process of pH adjustment/chemical precipitation and allows for reduced consumption of chemicals.	Potentially effective at removing metals and radionuclides when used in conjunction with another treatment process option. Innovative technology that would require treatability testing to determine effectiveness.	Equipment only available from one supplier.	Medium Capital Medium O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS
FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Treatment (continued)	Ex-Situ Physical/Chemical [a] *Separation* (continued)	Liquid Emulsion Membranes {NOT RETAINED}	Technology that uses liquid emulsion membranes to selectively extract metals from solutions. Process consists of iron precipitation with hydrogen peroxide, lime addition to raise pH, treatment of supernatant through a filter, extraction, and stripping operations.	Only effective for removal of selected metals. Innovative technology that would require treatability testing to determine effectiveness.	Innovative technology, not proven or developed to full scale.	High Capital Medium O&M
		Electrodialysis {NOT RETAINED}	Ionic species are removed from water through a membrane separation process.	Effective in removing metals and radionuclides from solution.	Complex system	High Capital Medium O&M
	Adsorption {NOT RETAINED}	Forage Sponge {NOT RETAINED}	An open-celled cellulose sponge incorporating an amine-containing chelating polymer that selectively absorbs dissolved heavy metals.	Effective for removal of heavy metals, but not radionuclides. Not effective for high contaminant levels, because frequent change-outs are necessary.	Difficult to use on sites with large treatment volumes or contaminant loadings.	Medium Capital Very High O&M
	In-Situ Physical/ Chemical	Passive Reactive Barrier (PRB) Wall	Contaminated water would be remediated through in-situ chemical reactions with chemically or biologically active materials contained in an installed subsurface wall. Zero valent iron is commonly used as a reactive medium. Other media may also be used, such as limestone or apatite.	Potentially effective for reducing metal and radionuclide concentrations at some parts of the site with shallow groundwater to reduce loadings of COCs from groundwater to surface water. Effectiveness would need to be determined through bench and/or pilot scale testing.	May be difficult to locate and install with subsurface conditions present and lack of an aquitard. Complexity of construction increases with depth. Construction may be further complicated if more than one reactive medium is needed.	High Capital Low O&M

EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER

Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Treatment (continued)	Ex-Situ Biological Treatment	Ex-situ Anaerobic Bioreactors / Sulfate Reducing Bacteria (SRB)	Bacterial reduction of sulfate, iron, and precipitation of metals sulfides in a suitable packed (carbon source) bed under anaerobic conditions. Biological reactions are utilized for chemical reduction of the wastewater COCs in an oxygen free environment.	Potentially effective for metals treatment, but would require treatability testing to identify effectiveness. Not effective for pH less than 5.5, therefore pretreatment would likely be necessary.	Technology has seen increasing use at mine sites. Difficult to maintain optimal conditions with changing carbon source, ambient temperature, and influent concentrations.	High Capital Medium O&M
		Constructed Wetlands {NOT RETAINED}	Wetlands would be used to create aerobic and/or anaerobic environments for the removal of dissolved metals and reduce suspended solids in the effluent. Natural geochemical and biological processes accumulate and remove metals. Sulfate-reducing microorganisms in the anaerobic zone of substrate material cause a breakdown of sulfate and the subsequent precipitation of sulfides.	Potentially effective at reducing loadings of COCs in water; however, long-term effectiveness for metals and radionuclides removal not well known. Changing conditions in the wetland may result in decreased contaminant removal rates over time.	May be difficult to find a suitable location to construct a wetland.	Medium Capital Medium O&M
		Ex-situ Biosulphide Process {NOT RETAINED}	An integrated two-stage chemical/ biological process which concurrently recovers metal and sulfide-based coproducts. Consists of sulfate-reducing bacteria process and precipitation process.	Innovative technology that would require treatability testing to determine effectiveness.	Complex system that has not been demonstrated at full scale.	High Capital High O&M

Table 2-8
EVALUATION OF RETAINED PROCESS OPTIONS FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

General Response Action	Remedial Technology	Process Option	Description of Process Option	Effectiveness [b]	Implementability [c]	Cost [d]
Treatment (continued)	In-Situ Biological Treatment	In-situ Bacterial Reduction	Introduction of bacteria and/or nutrients (carbon source) to promote naturally occurring bacteria to create reducing conditions, which promote the immobilization of metals.	Potentially effective at reducing loadings of COCs from groundwater to surface water. Effectiveness would need to be determined through bench-scale testing.	Not proven or developed to full scale. May be difficult to maintain optimal conditions for bacteria with changing subsurface conditions.	Medium Capital Medium O&M
		Phytoremediation {NOT RETAINED}	Direct use of plants and their associated rhizospheric microorganisms to remove, degrade or contain COCs in soils and water.	Potentially effective for limited parts of the site with shallow groundwater. However, there is a potential for human or animal exposure to COCs if plants are consumed.	Majority of site groundwater is too deep.	Medium Capital Medium O&M
Water Discharge	On-Site Discharge of Treated Water	Surface Water Discharge	Discharge of treated water to existing drainage or pond. Water would travel as surface water to Lake Roosevelt via Blue Creek.	Effective with successful operation of the existing WTP or other treatment process.	Proven option that is currently being used at the site. Water discharge must meet water discharge standards.	Low Capital Low O&M
		Aquifer Recharge {NOT RETAINED}	Treated water would be allowed to percolation into aquifer through shallow and/or deep injection wells, infiltration galleries, or surface irrigation (sprinkler system).	May be difficult to determine infiltration locations that don't negatively effect hydrology.		Medium Capital Low O&M

EVALUATION OF RETAINED PROCESS OPTIONS
FOR GROUNDWATER
Secondary Screening of Technologies and Process Options

{NOT RETAINED} with shading denotes remedial technology process option that will not be carried forward for additional evaluation.

[a] Residuals produced during ex-situ physical/chemical treatment of water will likely be managed using one of the off-site disposal process options presented on Table 2-1. 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.
[b] Effectiveness rates the technical effectiveness of the process to achieve the remedial action objectives for the medium of concern.
[c] Implementability is based on technical and administrative factors that affect the ability to implement the process.
[d] Costs are based on professional judgment and are relative to process options presented under a specific remedial technology type.

Notes: 1) Multiple response actions and remedial technologies may be combined to develop effective alternatives for groundwater.

2) Process options retained for additional evaluation may not be applicable to all locations of the site or material types present at the site.

3) 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.

4) If needed, treatability testing could be performed during the remedial design phase.