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Greens Creek Tailings Disposal

Final Environmental Impact Statement

Volume II

Appendices

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Volume II - Appendices

Appendix A

Hydrology and Geochemistry of the Greens Creek Tailings Facility, 2003

Appendix A
Hydrology and Geochemistry of the Greens Creek Tailings Facility

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1.0 Introduction

1.1 Background

The Greens Creek Mine is an underground zinc/silver/lead/gold mine, lying partially within the Admiralty National Monument on northern Admiralty Island, Alaska. The mine is located approximately 18 miles southwest of the city of Juneau. The Greens Creek mine began production in 1989 and mining was temporarily suspended from 1993 until July, 1996 and has continued to the present. Kennecott Greens Creek Mining Company (KGCMC) is planning an expansion of the existing tailings pile. Potential environmental, social and economic impacts that may be associated by the expansion are being evaluated as part of an Environmental Impact Statement (EIS). The EIS team has identified four project alternatives including;

- Alternative A - No Action – includes a carbonate or argillite acid neutralizing layer as required by the State solid waste disposal permit as part of cap over east expansion portion of pile.
- Alternative B - Proposed action – same as above except with original proposed boundary change.
- Alternative C – East Ridge and monument values boundary changes and analysis of role of carbon in the pile - without addition, added as a veneer if needed, or added continuously in combination with the tailings.
- Alternative D – continuous carbonate addition and expanded boundary as needed for additional volume.

1.2 Objectives

This report describes the hydrology and geochemistry of the tailings area. This report supplements the EIS by providing a detailed description of the amount and quality of water that may be affected by the tailings under each alternative. The site conceptual model of the tailings hydrology and geochemistry is described in chapter 2.0. The conceptual model is a narrative and graphical description of

- the sources of water that enter the tailings,
- the spatial extent, flow rate, and quality of "receiving waters" (a receiving water is natural surface water, groundwater, or marine water downgradient of the tailings facility and whose quality may be affected by the tailings),
- the nature of the connection between receiving waters and the tailings "contact water" (contact water consists of runoff or seepage (e.g. water flowing out of the base of the tailings) that has contacted tailings material), and

- the geochemical processes that occur within the tailings, the receiving waters and the zone where these mix.

Chapters 3 through 6 contain a description of a mass load model. The mass load model is a tool developed to evaluate potential environmental effects associated with each project alternative. As such, the model is a quantitative predictive tool that is structured to simulate the tailings conceptual model.

2.0 Tailings Conceptual Model

2.1 Location and Setting

The proposed alternatives for expansion of the Greens Creek tailings include placement adjacent to and on top of the existing tailings facility. A schematic of the existing tailings and expansion area are shown in Figure 1.

The tailings facility is operated to minimize impacts to water quality. Diversion ditches and slurry cut-off walls have been constructed to redirect surface and groundwater around the tailings. Contact water is collected and treated prior to being discharged to Hawk Inlet under a National Pollutant Elimination Discharge System (NPDES) permit.

The tailings facility will be reclaimed by placing a four layer engineered cover over the tailings to minimize the amount of water and oxygen that enters the tailings pile (USEL, 1998; Klohn Crippen, 2001).

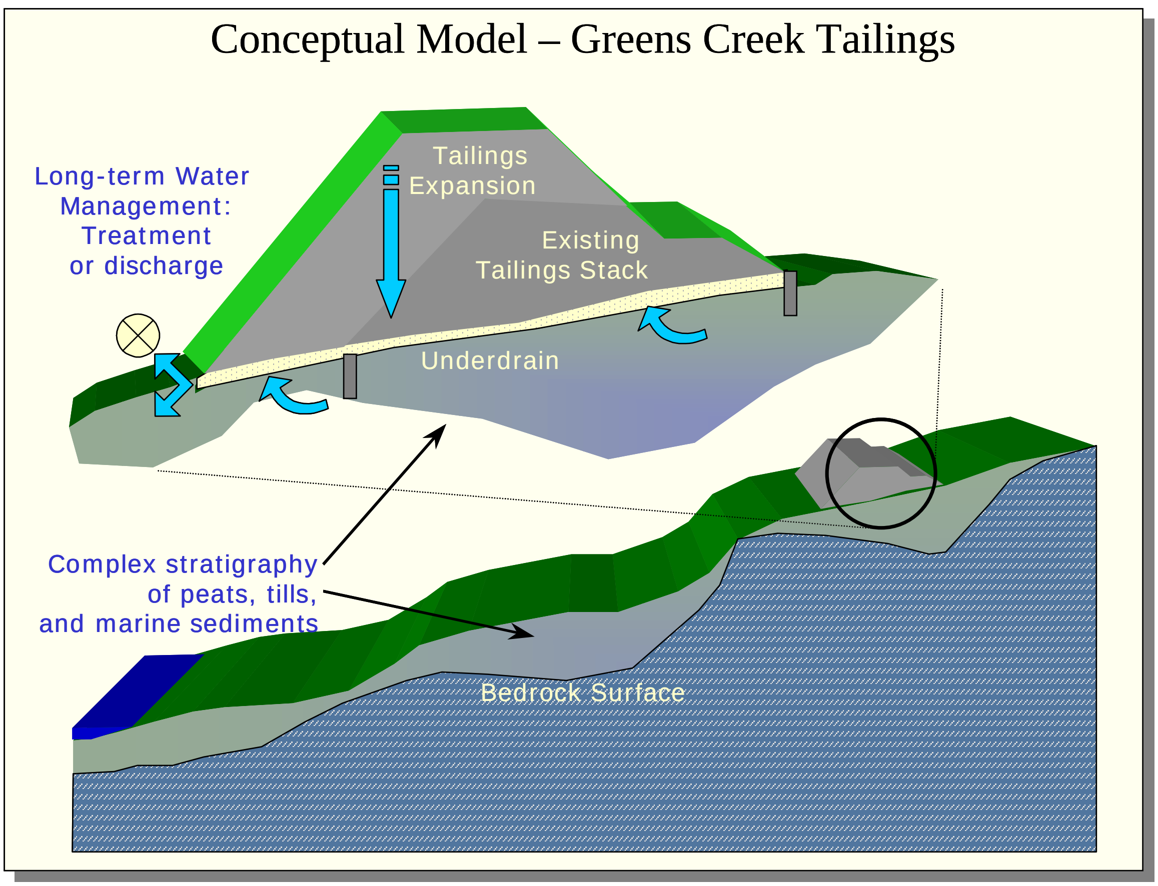

Figure 1. Conceptual model of the Greens Creek tailings and expansion area.

2.2 Climate

2.2.1 Precipitation and Snowpack

Southeast Alaska and Admiralty Island can be characterized as a temperate rain forest, which receives large amounts of rain, snow and fog. Annual temperatures in the region range between the mid 30s to the mid-upper 40s degrees F. The annual average temperature at the tailings site ranged between 41-43°F between 1997 and 2000. The minimum and maximum one-hour average temperatures at the tailings site in 2000 were –8.8°F and 70°F, respectively.

Regional precipitation amounts vary, depending upon orographic effects of the mountainous terrain and marine currents. For example, the average annual precipitation at Angoon on the south end of Admiralty Island is 42.2 inches, while Port Walter receives 225 inches. Juneau has four reporting stations that collect average annual precipitation: Juneau airport reports 56.5 inches; Auke Bay reports 62.4 inches; Juneau 9NW reports 74.8 inches; and Juneau 2 reports 88.3 inches. Average snowfall depths ranges between 65 inches in Angoon up to 98 inches at the Juneau airport. Precipitation periods are generally highest August through November, and lowest March through June. A monthly summary of Juneau airport precipitation from 1949-2001 is shown in Appendix 1. (Western Regional Climate Center, 2001).

Automated precipitation data have been collected at the tailings site since 1997. During the period of 1997 through 2000 the average annual precipitation at the tailings site was 53.0 inches compared to 68.9 inches in Juneau for the same period. A long term precipitation record for the tailings site was synthesized based on the Juneau airport data and the relative difference between the average annual rainfall at the airport and the tailings site (Figure 2).

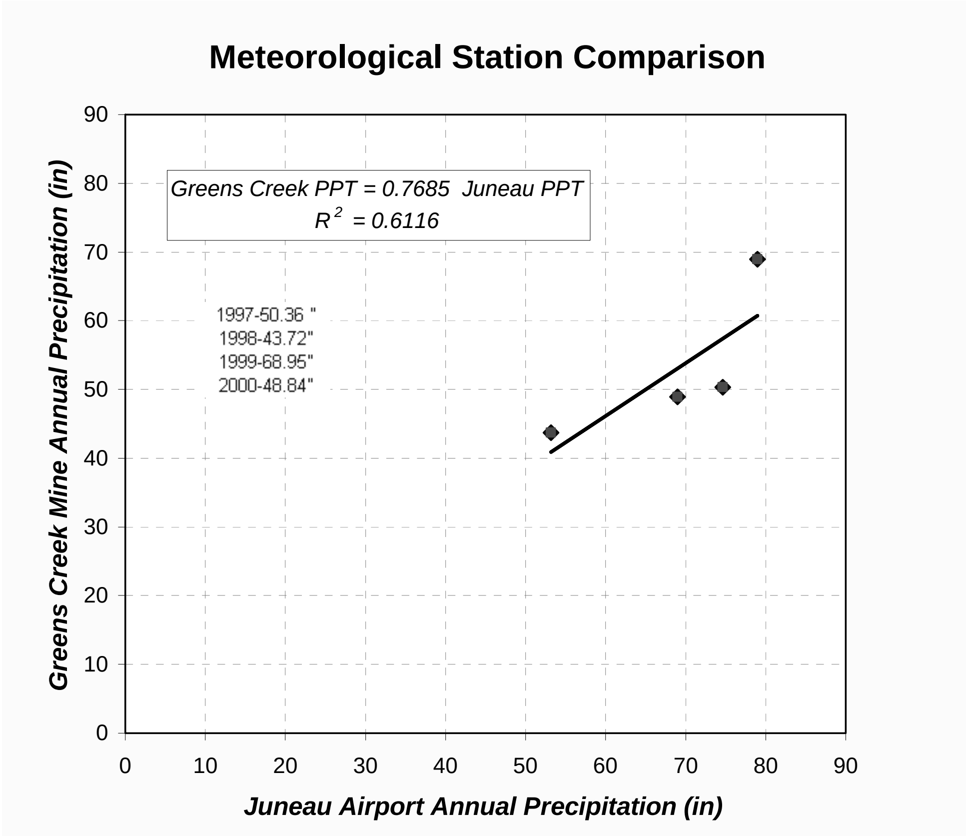

Figure 2. Comparison of precipitation at the tailings site and in Juneau.

2.2.2 Growing Season and Potential Evaporation

Due to the high amount of precipitation and the relatively cool temperatures, evaporation and transpiration amounts are relatively low at the tailings site. The balance of rainfall and evaporation off the reclaimed tailings surface are important factors that have been considered in the design of the engineered cover proposed for the tailings (USEL, 1998).

2.3 Potential Receiving Waters

2.3.1 Surface Water

The planned discharge from the tailings facility is to the Hawk Inlet drainage. This drainage area lies immediately to the west of the existing tailings facility and Tributary Creek. This catchment has an area of approximately 76 acres, of which approximately 5 acres are covered by hydraulically contained areas of the existing tailings facility (Figure 3). This drainage has a northern aspect, and consists of terraces intermixed by steep slopes. The vegetation is primarily muskeg and timber.

Several small streams form within the drainage area as a result of the seeps and surface water runoff. These streams are known locally as CC Creek, Proffett/Franklins Creek, and Further Creek (South Fork, North Fork)(Figure 3). CC Creek and Further Creek discharge directly to Hawk Inlet. Proffett Creek can be traced a few hundred feet on the surface before it sinks into the underlying strata. Another surface stream appears about 100 feet down gradient, and appears (based on similar water chemistry and physiographic position) to be the same water flowage. This lower stream is known locally as Franklins Creek, which discharges directly to Hawk Inlet. Water flow in these streams fluctuates seasonally in response to rainfall and snowmelt events. High flows generally occur in spring as a result of snowmelt, and again in fall as a result of high rainfall . Low flows typically occur in mid-winter and late summer. Stream flow data for these creeks are either non-existent or have not been collected in sufficient amounts to generate statistical indices based on actual flow measurements.

The muskeg-covered terraces also contain numerous seeps that are surface expressions of precipitation-induced recharge to the peat and sand substrate. One particular seep of interest is called Further Seep, an intermittent seep with a flow of approximately 1 gpm. Another surface water feature is a man-induced spring called Duck Blind Drain. This surface water feature has resulted from construction of the pipeline that discharges treated water into Hawk Inlet. Water that naturally collects within the pipeline trench alignment is allowed to discharge to the surface through a pipe at the location of a pipeline valve vault. This vault contains a flow meter that monitors flow through the pipeline, and the discharge pipe is used to keep the vault from becoming flooded. The flow from this source is less than 5 gpm.

The streams and seeps in the Hawks Inlet catchment were sampled during baseline data collection efforts in 2001. Samples were collected in Proffett/Franklin Creeks, CC Creek (2 sites), Further Creek (4 sites), Further Seep and the Duck Blind Drain. Table 1 presents a summary of water quality data for these surface water features.

Table 1. Surface Water Quality - Hawks Inlet Drainage

Analyte	C.C. Creek (2 sites)	Proffett/ Franklin Creek (2 sites)	Further Creek (4 sites)	Further Seep	Duck Blind Drain
Total Alkalinity, mg/l	ND	29-71	ND-13	ND	234
Hardness, mg/l	13-16	101-206	72-164	78-79	673
Conductivity, umhos/cm	21-29	198-382	131-303	342-377	1205
pH, s.u.	5.7-6.2	7.0-7.4	5.2-6.9	3.3	6.6
Arsenic, dissolved, µg/l	ND-0.6	ND	ND-2.1	ND-1.1	1.0
Barium, dissolved, µg/l	7.1-12.4	15.5-25.9	30.5-81.4	34.6-42.4	59
Cadmium, dissolved, µg/l	ND	ND	ND-0.6	0.2-0.3	ND
Chromium, dissolved, µg/l	1.6-19.5	ND-1.1	ND-19.8	1.1-1.9	ND

Analyte	C.C. Creek (2 sites)	Proffett/ Franklin Creek (2 sites)	Further Creek (4 sites)	Further Seep	Duck Blind Drain
Copper, dissolved, µg/l	1.4-7.2	ND	1.5-7.1	4.3-4.9	ND
Lead, dissolved, µg/l	0.28-0.87	ND	0.7-4.3	1.9-3.6	ND
Mercury, dissolved, µg/l	ND	ND	ND	ND	ND
Nickel, dissolved, µg/l	1.2-2.3	ND	2.3-7.4	6.8-7.8	65.9
Selenium, dissolved, µg/l	ND-1.8	ND	ND-1.4	ND	1.3
Silver, dissolved, µg/l	0.2-0.7	ND	0.2-0.5	ND-0.16	ND
Sulfate, mg/l	0.8-1.5	63-140	43-149	98-118	496
Zinc, dissolved, µg/l	3.9-5.0	ND	29.3-209	65.4-71.8	97.3

ND = non detect. (from EDE 2002b)

Water quality in Further Creek, Further Seep, and Duck Blind Drain differ from surface water quality seen in nearby Tributary, GR and Cannery Creeks (refer to Chapter 3 of the SEIS for a description of these drainage basins). Lower pH and higher sulfate and zinc concentrations are evident, however dissolved metal concentrations excepting zinc are within the range of other nearby streams. KGCMC notified the regulatory agencies of these water quality data, and proposed further characterization of the area in an action plan dated September 6, 2001. This action plan culminated in a rigorous evaluation of the groundwater, surface water and seeps around the tailings pile (EDE, 2002a, 2002b).

Conclusions drawn from this evaluation indicate that the lower pH and higher sulfate waters do not show a tailings contact (i.e., interstitial) water component. Rather, the source(s) are believed to be pyritic material (quarry rock, production rock or tailings) that lie (or once lay) outside the capture area for the slurry walls and clay/silt units underlying the tailings pile.

More specifically, the source of these anomalous waters in Further Seep area is believed to be residual effects of an old access road constructed in 1988 that contained pyritic rock. The road was located along a portion of the perimeter of the West Buttress. This road was removed during West Buttress and slurry wall construction. Observations of reduced impacts to vegetation in the seep area suggest that the source of acidity has been removed and that the quality of the seep is improving (EDE, 2002b). The North Fork South Spur of Further Creek has higher dissolved constituent loading than other locations within the Further Creek area. This is believed to be due to a thin veneer of tailings residue at the toe of the West Buttress. It is believed this residue accumulated during removal of the temporary PVC tailings cover in 1999. Another small exposure of tailings (8 cubic yards) was removed from the bank of the Northwest Diversion Ditch located at the northwest corner of the West Buttress. This was also believed to be contributing to the Further Creek load. In 2002 KGCMC routed the Northwest Diversion Ditch into the West Buttress Ditch (thus diverting the water to the tailings water treatment system), and removing accessible tailings residue from the toe of the West Buttress Ditch, along with additional monitoring of these waters.

The source of dissolved constituents in Proffett/Franklins Creek and Duck Blind Drain appears to be an access road and trench construction materials used for the NPDES discharge pipeline and associated utilities. This pipeline trench provides a preferential flow path for water along a portion of the western perimeter of the tailings pile. It is believed that the pyritic quarry rock used for pipe bedding and backfill contains carbonate mineralization but lacks zinc mineralization, which controls the water composition of Duck Blind Drain and ultimately Profett/Franklins Creek. KGCMC has proposed installing a pump in Duck Blind Drain and routing the water to the water treatment plant, as well as continued monitoring of these waters.

2.3.2 Groundwater

Analyses of water quality samples from wells located within the Hawk Inlet drainage indicate some anomalous (i.e., high relative to background) sulfate concentrations. Higher concentrations of metals and lower pH values were not observed in these wells. The wells include MW-01-15C, MW-01-03B, and MW-01-03A on the west side (Figure 4). An extensive evaluation was conducted to determine the source(s) of the higher sulfate values (EDE, 2002b).

An evaluation of the west-side wells concluded that water in the shallow sands may have come into contact with water from Further Seep, pyritic rock and/or tailings prior to slurry wall construction. Two possible sources for the elevated sulfate in the west-side bedrock wells are the bedrock knob near the northwest corner of the tailings pile and the northern terminus of the West Buttress slurry wall where it keys into bedrock. The influence of the higher sulfate concentrations appears to be localized, and there is an absence of a contact water signature (e.g. elevated TDS and zinc concentrations) associated with these sulfate concentrations. Therefore, it is believed that the bentonite slurry walls and clay/silt sedimentary units are performing well with respect to capturing and preventing migration of tailings contact water. KGCMC proposes to collect additional water elevation data on either side of the slurry wall beneath the West Buttress to help confirm the sulfate source in this area

Figure 3. Map of tailings area showing surface water drainages.

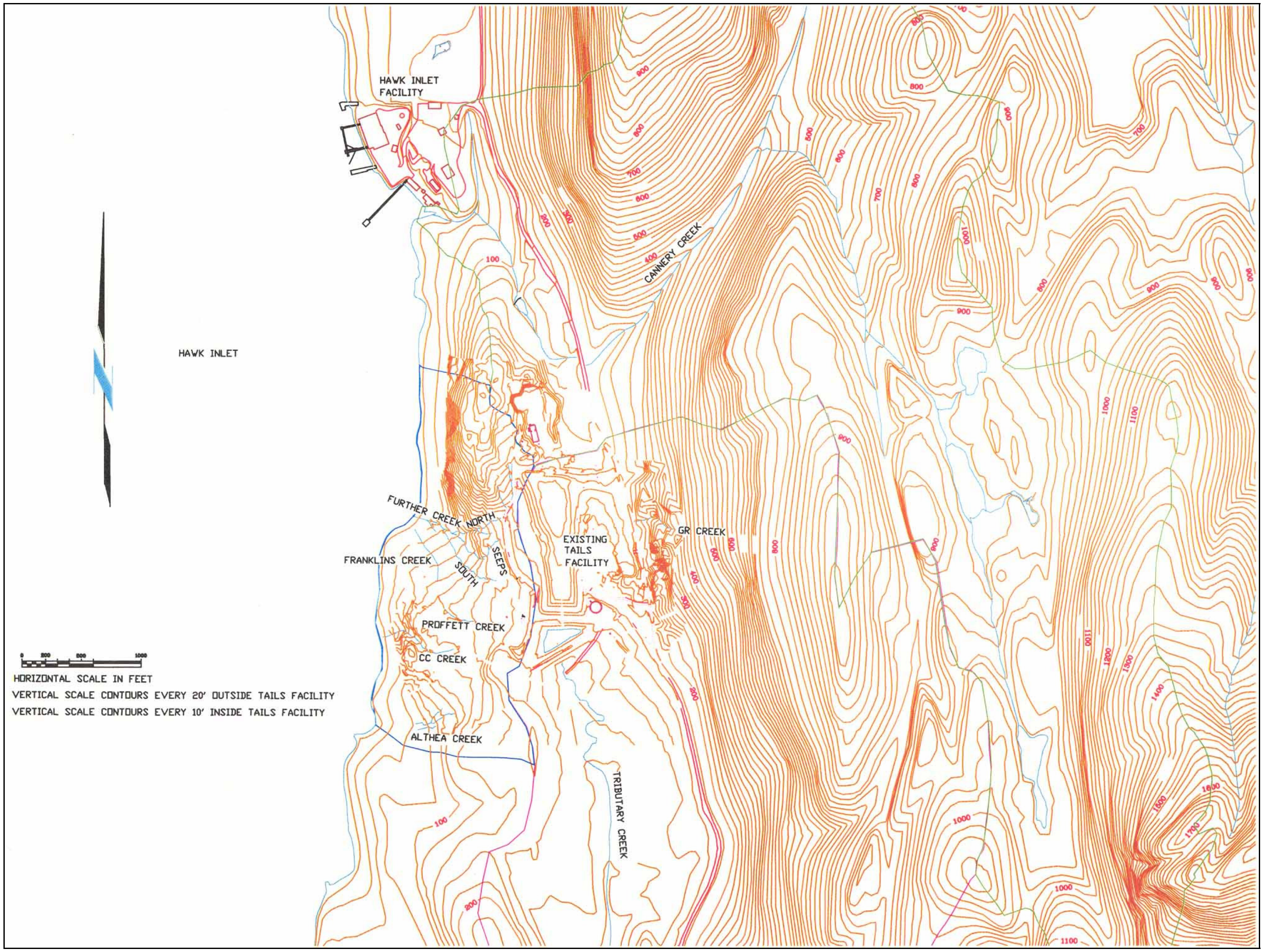

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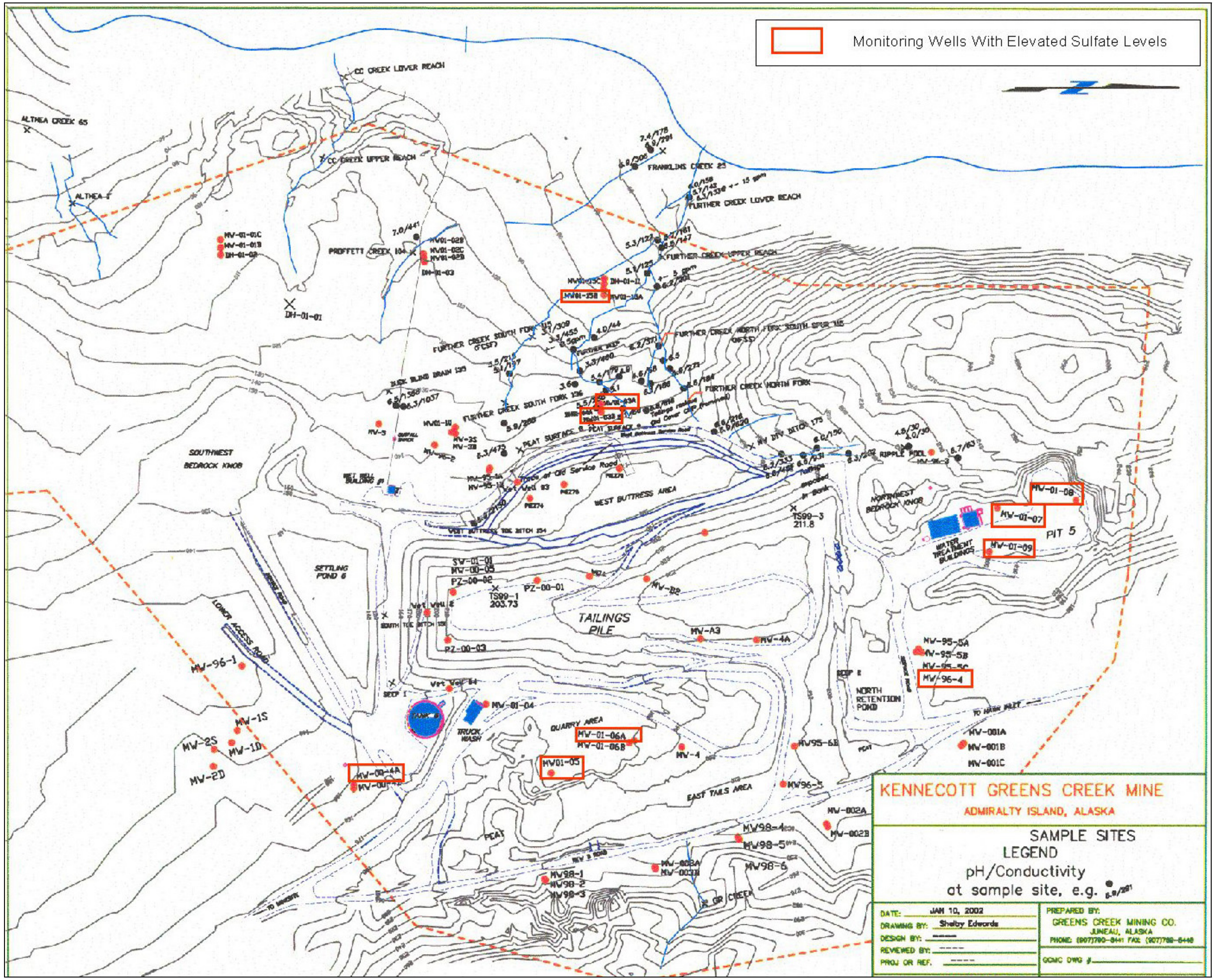
Figure 4. Map of tailings area showing groundwater features.



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2.3.3 Hawk Inlet

Hawk Inlet extends 7 miles north from Chatham Strait and ends in a tidal mudflat estuary about 0.6 miles in diameter. The bathymetry of Hawk Inlet consists of a narrow basin, partially separated from Chatham Strait by a relatively shallow sill that includes a delta at the mouth of Greens Creek. The mid-channel depth ranges from 35 feet at the sill, to 250 feet in the mid-portion of the inlet. Near the mouth of the inlet there is a large delta formed by glacial activity and by river-borne sediments of Greens Creek. Flushing studies in Hawk Inlet using dyes were conducted in 1981. Based on these studies, it was estimated that over each tidal cycle, an average of 50×10^6 cubic meters (13×10^9 gallons) was flushed from the inlet. Projected flushing for the entire inlet based on these estimates is that the inlet will completely flush at least once every 5 tidal cycles. On a percentage of volume basis, the input of effluent over this flushing period represents approximately 0.009 percent of the total flushing volume (Andrews, 1996).

The discharge pipeline from the water treatment plant is routed into Hawk Inlet west of the tailings site. This pipeline culminates in a diffuser which distributes effluent into the waters of Hawk Inlet. The diffuser is a 14-inch diameter, 160-foot long pipe laid along a submarine slope.. The shallow end is located at a water depth of approximately 45 feet MLLW and the offshore end at a depth of approximately 69 feet MLLW.

2.3.4 Relevant Alaska Water Quality Standards

Hawk Inlet and Chatham Strait are classified by the AWQS as Classes 2(A)(i)(ii)(iii), 2(B)(i)(ii), C and D. The water is designated for all uses, i.e., aquaculture, seafood processing, and industrial water supply uses; water contact and secondary recreation uses; growth and propagation of fish, shellfish, other aquatic life and wildlife; and harvesting for consumption of raw mollusks or other raw aquatic life.

The surface water and groundwater of the Hawk Inlet drainage basin are classified by the AWQS as Classes 1(A)(i)(ii)(iii)(iv),1(B)(i)(ii), and C. The waters are designated for all uses, i.e., drinking, culinary, and food processing, agriculture, aquaculture, industrial; water contact and secondary recreation uses; and growth and propagation of fish, shellfish, other aquatic life and wildlife.

The State of Alaska adopted water quality standards 18 AAC 70 as amended through June 26, 2003. These standards contain values for the metals freshwater and marine water criteria. The metal concentrations predicted in the mass load model were compared to the chronic freshwater and marine water criteria. Freshwater criteria are dependent on hardness. The equations below (Table 2) derive the total recoverable criteria.

Table 2. Equations for deriving freshwater AWQS chronic criteria for metals.

Parameter	Chronic Freshwater Criterion			
	Coefficient a	Coefficient b	Coefficient c	Coefficient d
Cadmium	0.7409	-4.719	1.101672	**0.041838**
Chromium III	0.819	0.6848	**CF = 0.860**	
Copper	0.8545	-1.702	**CF = 0.960**	
Lead	1.273	-4.705	1.46203	**.145712**
Nickel	0.846	0.0584	**CF = 0.997**	
Silver (acute only)	1.72	-6.52	**CF = 0.850**	
Zinc	**0.8473**	**0.884**	**CF = 0.986**	

Dissolved Criterion (micrograms/L) = CF * exp[a * ln(hardness) + b]

Where CF is a correction factor that is hardness dependent for cadmium and lead and is a fixed value for other constituents. The hardness dependent correction factor is derived from:

c – [ln(hardness) * d]

The mine has a NPDES permit to discharge effluent into Hawks Inlet (Outfall 002). Effluent limitations for this outfall are shown in Table 3. These limits are technology based, rather than water-quality based. During the post-closure period, the discharge permit will be re-issued to reflect the expected discharge rates and water chemistry. At that time, EPA will determine whether water quality based effluent limitations would apply, or if best professional judgment (BPJ) based limits would apply.

Table 3. Effluent Limitations for Outfall 002

Effluent Parameter	Effluent Limitation [1]	
	Average Monthly Limit	Maximum Daily Limit
Flow (mgd)	1.66	3.6
Cadmium (µg/l) [2]	50	100
Copper (µg/l) [2]	150	300
Lead (µg/l) [2]	300	600
Mercury (µg/l) [3]	1.0	2.0
Zinc (µg/l) [2]	500	1000
TSS (mg/l)	20	30

NOTES:
1. Limitations on daily discharge
2. These parameters shall be analyzed as total recoverable.
3. Mercury shall be analyzed as total.
Source: Permit No.: AK-004320-6

2.4 Tailings Placement and Physical Characteristics

The Greens Creek mill removes ore concentrates using a chemical flotation process and the materials left after removal of economic metals are called tailings. After processing, the tailings are partially dewatered in a filter press and then roughly one half of the tailings are placed in the underground mine as backfill. Remaining tailings are placed on the dry tailings pile.

2.4.1 Tailings Characteristics

The tailings, consisting of predominantly silt-sized particles and residual process water, are delivered to the tailings facility by truck. Tailings are 76 to 96 percent finer than a 200 mesh (0.075 mm) sieve, and contain 5 to 13 percent clay. Tailings have 12 to 14 percent water by weight (26 to 30% by volume) when they leave the mill. After placement, tailings have a dry bulk density of 2.15 g/cm3 (134 lbs/cu. ft.) and a particle density of 3.6 g/cm3 (EDE 2002b). The porosity is approximately 40 percent, of which 64 to 75 percent is water-filled when initially placed in the pile.

2.4.2 Tailings Facility Operation

Materials are placed in the dry tailings facility in thin lifts and in the current plan will create a mound approximately 80 feet thick. Up to an additional 80 feet of tailings placement is planned in the expansion. The facility is designed and operated to keep the tailings moist but not saturated. This minimizes the development of seepage and also insures that the pile is geotechnically stable.

The unsaturated hydraulic properties of tailings are important in determining the rate of water and oxygen movement within the tailings. The residual water content in unsaturated materials depends on the suction level, which usually ranges from 100 to 300 cm in the bulk of the pile between the zone of evaporation (near the surface) and above the water table and capillary fringe at depth. Residual water content averaged 31.3 % in three samples of tailings collected beneath the zone of evaporation in 2001 (Table 4). The estimated residual water content was independently estimated based on hydraulic properties of tailings material. The UNSODA database (Nemes et al. 1999) was used to find a silt loam soil with a gradation similar to the tailings, with low organic carbon, and no structure. A good matching curve (sample 4510) was found, and the saturated water content of 41 % matched the porosity of 40 % calculated for the Kennecott tailings. The suction corresponding to fully-drained conditions (100 to 300 cm) yielded a residual water content of 31 to 36 %, which is in good agreement with the measured value (Figure 5).

Table 4. Residual water content of tailings samples.

Sample	Sample 1 (2 foot depth)	Sample 2 (2 foot depth)	Sample 3 (2 foot depth)
Wet+Tare (grams)	1401	1347	1155
Tare (grams)	656	520	539
Dry+Tare (grams)	1308	1236	1080
Wet Wt. (grams)	745	827	616
Dry Wt. (grams)	652	716	541
Moisture Wt. (grams)	93	111	75
Gravimetric Water Content (g/cm^3)	14.3%	15.5%	13.9%
Bulk Density (g/cm^3)	2.15	2.15	2.15
Volumetric Water Content (cm^3/cm^3)	30.7%	33.3%	29.8%

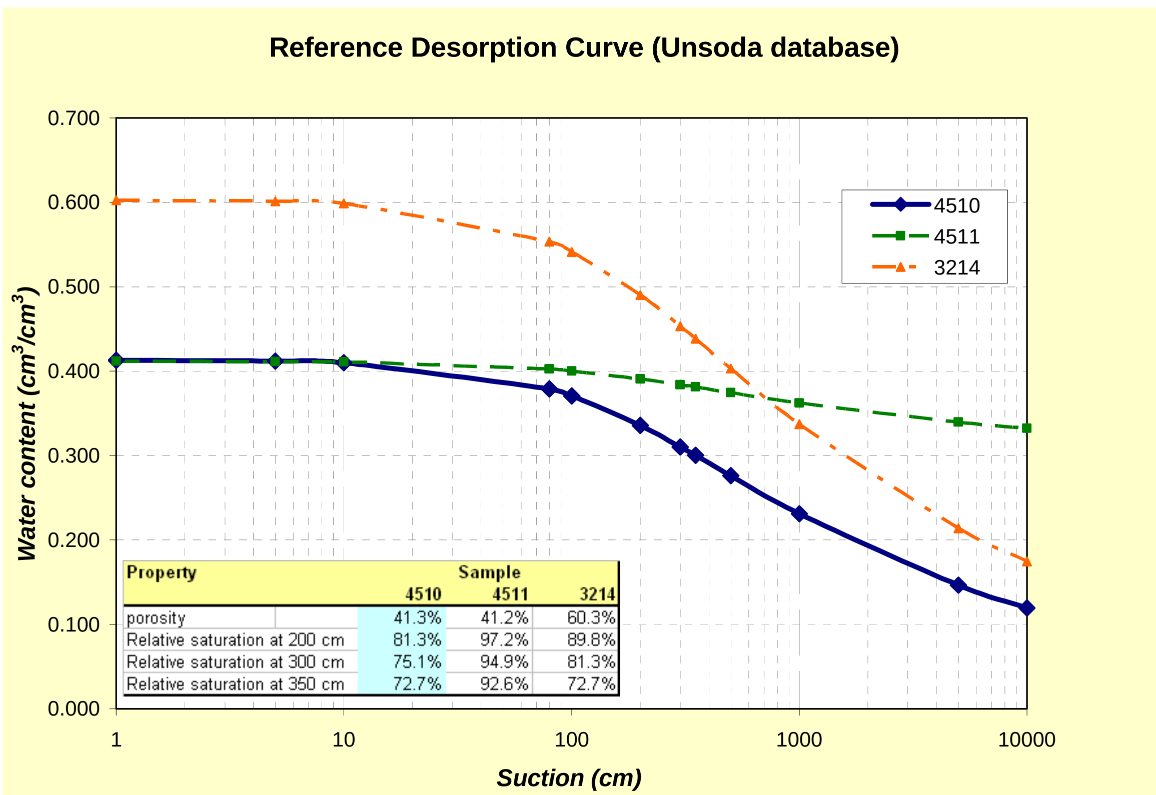

Figure 5. Desorption curves for three silt loam samples from the UNSODA database. Sample 4510 was used to represent the Kennecott tailings.

Tailings are transported onto the facility on gravel causeways that are built of production rock or borrow material. Tailings are then placed in cells that are compacted to 90% of their Proctor density. The fine texture, compaction, and unsaturated nature of the tailings also reduce acidification and metal leaching potential by minimizing infiltration of water and limiting diffusion of oxygen. At closure, an engineered cover will be placed and the facility is to be revegetated to stabilize the site and continue to minimize seepage and oxidation processes.

Development of the Greens Creek Mine tailings facility commenced in 1988 with construction of the main and saddle dams of Containment Pond No. 6, the surface water collection system, and the finger drains. Historically, tailings have been deposited in four areas, referred to as the Old Tailings Pile, the Active Tailings Pile, the West Buttress and the East Expansion. A summary of tailings pile development from Klohn-Crippen (2000) follows:

- Tailings placement began in early 1989 starting in the northwest comer of the Old Tailings Pile progressing south and east. In 1993, tailings placement ceased with the suspension of mining operations for a period of approximately three years. A total of approximately 735,000 yd^3 of tailings were placed in the Old Tailings Pile between 1989 and 1993.
- During the period of shutdown approximately 75,000 yd^3 of development rock was placed over the Old Tailings Pile to limit erosion during the inactive period. In August 1995, a geomembrane was placed over the Old Tailings Pile.
- The mine re-opened and tailings placement resumed in July 1996. Tailings placement started north of Containment Pond No. 6 Berm in the Active Tailings Pile located south of the Old Tailings Pile. The dry tailings placement area was expanded during this time in conjunction with changes to the water treatment system.
- Construction of a stabilizing berm (West Buttress) for the Old Tailings Pile commenced in late 1998. The construction of the main structure of the West Buttress with compacted tailings is currently on-going. The West Buttress is being raised on a prepared foundation.
- Construction of an East Expansion area commenced in 2000 to increase the capacity of the tailings facility. The East expansion design includes numerous water management features including a full blanket drain, an upgradient diversion ditch and slurry wall to divert surface and groundwater around the tailings.

2.4.3 Tailings Water Management

The current and expanded designs include provisions for diverting upgradient surface and some subsurface water around the tailings using diversion ditches and slurry cut-off walls. Precipitation falling directly on the tailings pile either runs off or infiltrates into the pile. Water that infiltrates flows downward, mixing with the tailings process water in the pore spaces, to recharge the water table within the tailings pile. This water then discharges to a system of finger drains and blanket drains that were constructed under the existing tailings. This drain system contains saturated and unsaturated zones. Water that runs off the reclaimed pile during the operational and closure phase is collected and treated prior to discharge. Water that runs off the reclaimed pile post-closure will either be routed into a water management system to dilute the underdrain water prior to discharge or directed as sheet flow into the adjacent forest. Appropriate design measures will be used to reduce water velocity and to minimize erosion.

Groundwater in aquifers beneath the pile has an upward gradient beneath the current tailings and also occurs under flowing artesian conditions on the southeast side of the pile. Consequently, upgradient groundwater discharges upward into portions of the underdrain system and mixes with interstitial water that is flowing downward from the tailings stack.

The tailings expansion will also employ an underdrain system. If the groundwater conditions are similar in the expansion area, a similar design may be used for the expansion. If upward groundwater gradients are not sufficient to provide containment of contact water, the facility design in the expansion area will also utilize a liner system to prevent discharge of tailings water into groundwater beneath the tailings.

Consequently, all interstitial water that flows out of the tailings post-closure is understood to be collected in the underdrain system. The water in the underdrain will consist of a mixture of interstitial water draining vertically downward out of the tailings and upward-flowing groundwater. Generally, groundwater will not contact tailings prior to entering the underdrain except possibly in strongly artesian zones or in areas where drain capacity is insufficient to convey the flux of the combined groundwater and tailings waters from beneath the tailings. However, the groundwater does encounter mineralized drain rock obtained from local borrow areas.

Post-closure, water flowing out of the underdrains will either be discharged without dilution under gravity to the surface or subsurface (discharge scenario 1(a), SEIS Section 2.2); diluted with surface runoff from the pile and downgradient groundwater prior to discharge to the surface or subsurface (discharge scenario 1(b); discharged to marine waters with the potential for dilution from a marine mixing zone (discharge scenario 2); or discharged to marine waters using a diffuser (discharge scenario 3). It is possible that discharge scenarios 1(a) and 1(b) may involve the use of a low-maintenance biological treatment system (a.k.a. treatment works) constructed at the land surface or subsurface. Underdrain water will continue to be collected and treated using a conventional chemical precipitation water treatment facility until such time the water quality meets the standards applicable to one of the selected discharge scenarios described above. Under discharge scenarios 1(a), 2, and 3, runoff from the reclaimed surface of the tailings will act as sheet flow onto the adjacent forest floor. Appropriate design measures will be used to reduce water velocity and to minimize erosion. While this modeling effort will not evaluate water management options, the predicted flow rate and chemistry of underdrain water relative to receiving freshwater and marine water will assist evaluation of the feasibility of treatment and discharge options.

2.5 Sources of Tailings Contact Water

2.5.1 Wet Well Flow Records

Contact water in the tailings facility comes from three sources; surface runoff, seepage through the tailings pile, and upwelling groundwater. Though upwelling groundwater does not directly contact the tailings, it encounters mineralized drain rock and mixes with tailings seepage within the tailings drain system and therefore requires treatment. The relative contributions of each of these sources are important in understanding water storage and treatment capacity during operations, and are also important in determining potential water quality impacts after the facility is closed. After placement of the engineered cover, surface runoff will no longer contact tailings. If this water is not used to dilute underdrain water, it will change from being classified as contact water (a.k.a. process water) to become stormwater (a.k.a. unclassified water), which can be discharged without treatment.

The best available data for estimating the proportions of contact water from each source are the daily flow records for the wet wells. Contact water flows into the wet wells from the drains (consisting of tailings seepage and upwelling groundwater) and from surface runoff. Runoff occurs from tailings facility itself and from a small area of the natural landscape that is captured by the wet wells (EDE 2001).

The method used to distinguish between the contributions of surface runoff from the drain flow is called baseflow separation. Baseflow generally refers to flow in a stream absent any influence from rain or snowmelt. In this analysis baseflow refers to the flow from the drain system. Several graphical and empirical methods have been used to separate baseflow from runoff. The simplest method of determining baseflow is to identify the lowest flow rate during the annual hydrograph and to assume that this represents baseflow. This method, which was used by EDE (2002), may underestimate baseflow in small hydrologic basins in Alaska because baseflow during different seasons may occur at different flow rates

An empirical baseflow separation technique developed as part of the HYSEP model by the USGS (Sloto and Crouse 1996) was used to identify runoff and baseflow from the wet well data. Of the three baseflow separation techniques available in HYSEP, the local minimum method appeared to provide the most realistic estimates of baseflow. In the local minimum method [1], the daily flow is compared to all flows in a time range corresponding to:

[0.5(2N*-1) days], where $N^* = A^{0.2}$, and A is the watershed area in square miles [1]

The value of 2N* used in the baseflow determination corresponded to a time period of three days. Baseflow was determined from the wet well data by connecting the “local minimum” values determined from [1]. Using flow data from wet well #2, the baseflow curve can be developed as shown in Figure 6. Table 5 identifies the estimated baseflow and runoff for the period of available record for wet wells #2 and #3. Data from wet well #4 are considered unsuitable for determination of baseflow and runoff because of possible subsurface connection between wet well #4 and North Retention Pond.

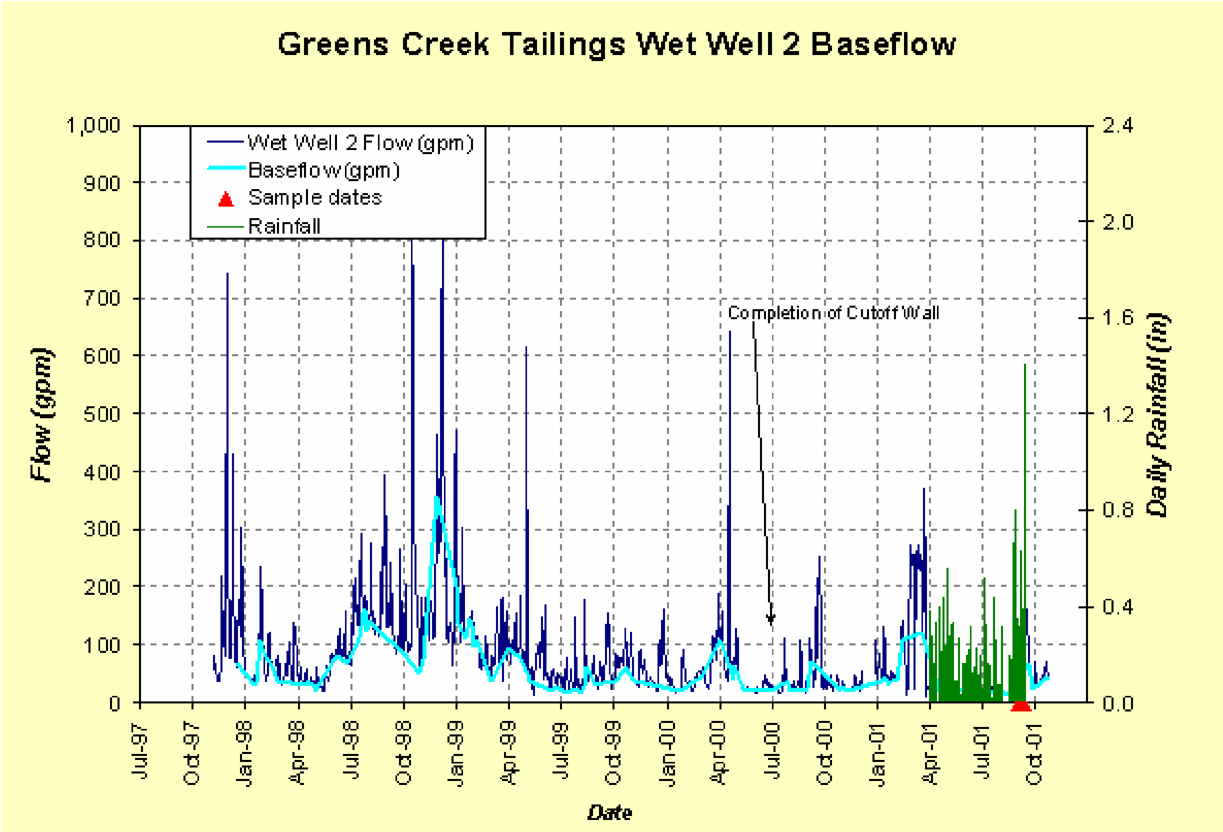

Figure 6. Recorded flow in wet well #2, and corresponding baseflow determined from the HYSEP model.

Table 5. Estimated average flow, baseflow, and runoff from wet wells #2 and #3.

Facility	Underdrain area (Acres)	Runoff area (acres)	Period of Record	Average Flow	Baseflow (gpm)	Runoff
Wet Well 2	14.6	12.2	11/9/97 to 10/23/01	77.9	55.6	22.3
Wet Well 3	3.7	3.7	10/28/00 to 10/23/01	10.1	6.9	3.3
Wet Well 4	4.3	4.3	1/20/01 to 3/31/01	13.3	nc	nc
				Average Flow	**Baseflow (in/yr)**	**Runoff**
Wet Well 2				103.3	73.7	29.6
Wet Well 3				52.9	35.9	17.0
Wet Well 4				nc	nc	nc

The estimated contributions of runoff and baseflow based on historical wet well flows may not accurately reflect the recently-completed slurry cutoff wall constructed east of the tailings facility in 2000 and early 2001. Consequently, a baseflow separation was determined for combined flows in wet well #2 and #3 for the period from February 1, 2001 (after completion of the slurry wall) until November 2001, the end or the period of record (Figure 7). The results of this analysis are described in the following sections (Appendix 2).

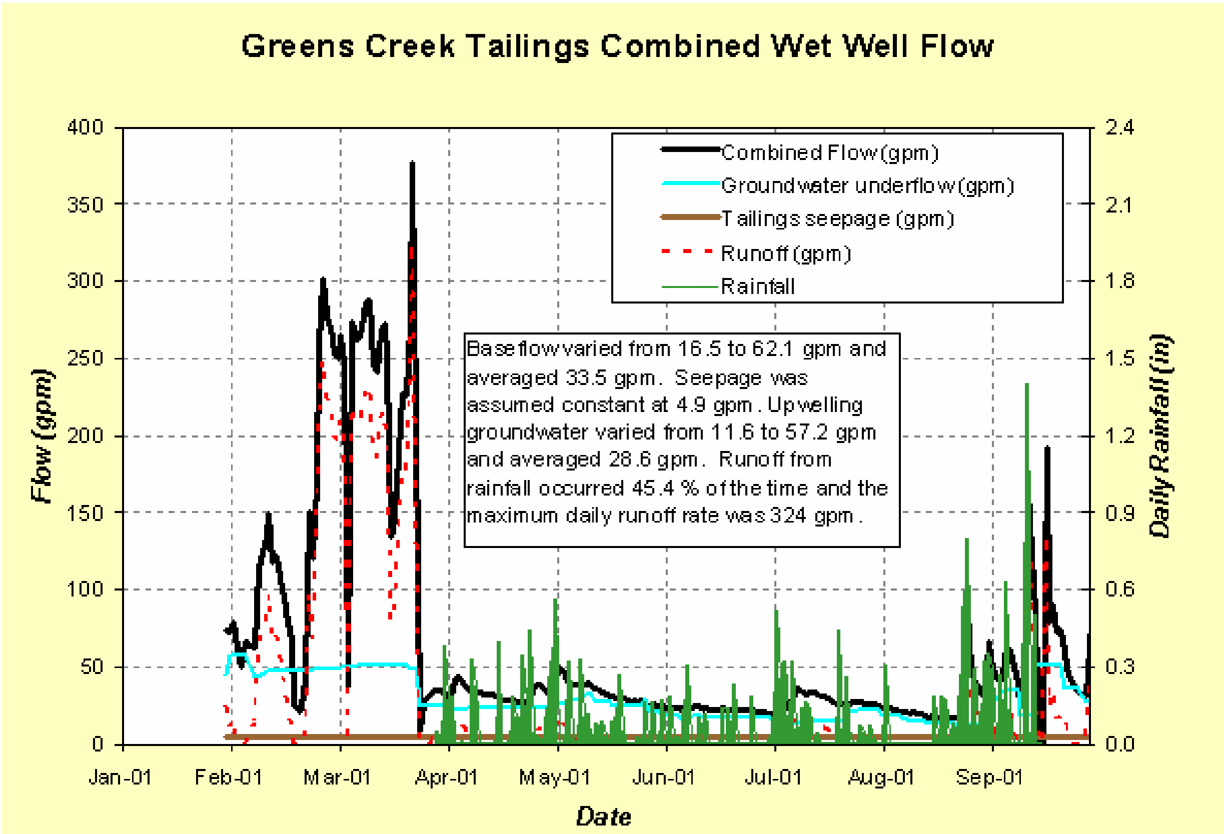

Figure 7. Flow in wet wells #2 and #3, estimated seepage, upwelling groundwater, and runoff.

2.5.2 Surface Runoff

For the period of February through October, 2001, runoff occurred approximately 45 % of the time, and the maximum observed runoff rate was 324 gpm. Rainfall was recorded on roughly 64 % of the days for the same period of record, meaning that shorter-duration or smaller rainstorm events did not tend to produce runoff. The average contribution from runoff was 29.0 gpm, which was 46.4 % of the total flow received by the wet wells. This combined flow rate is much lower than the flows recorded in 1998, which may reflect the influence of the new slurry wall or other improvements in the water and tailings management system.

2.5.3 Groundwater Underflow

The remaining 33.5 gpm received by the wet wells is from baseflow, the combined effect of groundwater underflow and infiltration and seepage through the tailings. While there is no direct means of separating tailings seepage from groundwater underflow, the tailings seepage was separately estimated by EDE (2001) based on the rate at which a groundwater mound developed in the tailings after removal of the geomembrane cover. Based on this estimate of 7.7 x 10^{-5} gpm/ft^2, the rate of tailings seepage was found to be 12 % of annual precipitation, which was 52.99 inches for the period of time during which the seepage analysis was computed. For the period of record a 12 % rate of infiltration would create a constant seepage rate of 4.9 gpm. Consequently, the average upwelling groundwater flux was 28.6 gpm, and varied from 11.6 to 57.2 gpm.

2.5.4 Infiltration and Seepage

Seepage Estimate Based on Mound Formation

Infiltration into the pile was estimated by analyzing the response of the water table to changes in infiltration created by placement of a temporary cap over the pile from 1995 to 1997. During the time the cap was in place, the water table declined by approximately 12.5 ft (EDE, 2002a). Following cap removal, the water table returned to its higher level. Using a water balance approach, the average rate of infiltration to the uncovered pile was estimated as 7.7×10^{-5} gpm/ft^2. Using a pile surface area of 29 acres, total annual infiltration is estimated to be 9.73 gpm, or 5.11 million gallons per year, or 683,000 cu ft/yr or 0.541 ft/yr, or 6.49 in/yr.

Seepage Estimate Based on Wet Well Baseflow

The seepage rate was assumed to be a constant value corresponding to 12 % of precipitation for the wet well baseflow analysis.

Seepage Estimate Based on Professional Judgment

The various infiltration coefficients computed for the tailings during the operating period generally range from 10 to 15 % of annual precipitation. These values seem lower than expected for bare tailings material based on experience at other mine sites where infiltration into fine materials may approach 30 % of annual precipitation and close to 50 % into coarse materials. The lower infiltration coefficient at Greens Creek may be a result of the low permeability of the compacted tailings material and the high annual precipitation compared to other sites.

If the estimated seepage rates are too low, then subsequent mass load calculations may underestimate the contribution of seepage during operations, and overestimate the contribution of upwelling groundwater. After placement of the engineered cover, the infiltration coefficient is expected to decrease to 10%. Consequently, an error in calculating the rate of seepage during operations would not affect the predicted rate of seepage after closure, but may cause the upwelling groundwater to be slightly over-estimated. However, even if the operational seepage rate was twice as high, the upwelling groundwater would only decrease from 28.6 to 23.7 gpm, a 17 % decrease. Consequently, the representative range of values used in the mass load model (chapter 3.0) to predict surface runoff and upwelling groundwater flux are considered reasonable.

2.6 Tailings Contact Water Quality and Geochemical Processes

2.6.1 Tailings Acid Rock Drainage Risk

Tailings at the Greens Creek Mine were derived from zinc, silver, lead and gold-bearing rocks mined from deep underground. The Greens Creek ore is a massive sulfide deposit meaning that the tailings contain an abundance of pyrite, one of the non-economic minerals that are not removed as ore concentrate during processing. When exposed to oxygen, pyrite will slowly weather, generating heat and dilute sulfuric acid. If acidic pH conditions develop in mining wastes (especially pH less than 4.0), metals and sulfate contained in the material become more soluble than they are when the pH remains alkaline (above a pH of 7.0). Consequently, acid-generating mine wastes are more likely to degrade water quality if solutions that contact the mine waste are released and mix with receiving water.

Calcium carbonate and dolomite are also abundant in the host rocks for the Greens Creek deposit. Greens Creek tailings contain both pyrite and carbonate minerals. When the tailings weather, the acid formed by sulfide oxidation is neutralized by carbonate minerals. The relative abundance of pyrite and carbonates determines whether acidic conditions will form or the material will retain an alkaline pH because of the carbonates. The balance of acid forming and acid neutralizing minerals in mine waste is determined using the static test.

Geochemical Test Results – Static Tests - The static test (Sobek et al. 1978) quantifies the acid generating and acid neutralizing capacity of a sample. The acid-generating potential or AGP is determined from the measured abundance of sulfide minerals in a sample while the acid-neutralizing potential or ANP is based on the carbonate abundance. The ANP minus the AGP is the net neutralization potential or NNP for a sample. Samples with NNP values less than –20 (measured in tons of $CaCO_3$ per 1,000 tons of material), have a risk of becoming acidic if they are exposed to oxygen (Miller et al. 1997). If the NNP is greater than +20 (or if the ratio of ANP to AGP is greater than 3.0 in some guidelines such as BC Research 1989), then materials are considered to be safe from ARD risk. The long-term behavior of materials with intermediate NNP values is uncertain.

Static testing of tailings from the Greens Creek deposit (Figure 8) indicates that they have the potential to become acidic. However, owing to the abundance of calcium carbonate and dolomite in the samples (generally ranging from 10 to 60%), a long period of weathering, estimated at more than 10 to 33 years in lab tests conducted on siliceous waste rock samples, would have to occur prior to development of acidic conditions. Before mining, the lag period for siliceous waste rock was estimated to be 22 to 33 years (Vos 1993). This estimate was based on the assumption that oxidation rates observed during 2 years of humidity cell and column tests would continue at the same rate indefinitely, and that acidic conditions would occur when all but 26 to 38 % of the original carbonate been removed. In a subsequent test Vos (1994) removed carbonates by leaching with acid to determine the leachate chemistry that would form after dissolution of all carbonates within the siliceous waste rock. He estimated on the basis of this evaluation that acidification would not occur for more than 10.9 years. Given that it is the top, most recently applied layer of tailings that is most exposed to oxygen and water and thus acidification, this time period would provide ample time for application of site closure technologies (e.g. the cover) to mitigate the ARD risk.

Vos (1990) also conducted geochemical evaluations of a tailings sample, which provided variable estimates of ARD risk. Static tests indicated that the tailings were potentially acid generating because of the abundance of pyritic sulfur. When the BC confirmation test was conducted in two ways, results indicated ARD risk to be “none” to “marginal”. Humidity cell test results through 26 weeks were presented by Vos (1990). The tailings humidity cell and column tests were extended for 573 days as reported by Smith (1991). Based on the extended humidity cell testing, Smith concluded that the tailings were relatively unreactive, that the tailings were unlikely to generate acid, and even if any acid were generated it would be consumed within the tailings mass without being released.

An estimate of lag period in tailings was based on comparison to waste rock lag periods, and on modeling of the results of measured rates of pyrite oxidation in tailings kinetic tests. The evaluation of tailings conducted by Vos (1990) and evaluated by Smith (1991) indicated that the tailings may not become acidic, though the results were not internally consistent and some tests suggested a risk of ARD development. Recent grab samples of tailings (Figure 8) show that many samples have a lower NNP than the Vos tailings sample. Consequently, the overall tailings are more safely considered to have a risk of generating locally acidic conditions, especially near the surface where oxidation is more prevalent. During operations the oxidation rate in tailings would likely be less than occurs in waste rock especially as long as new tailings, which inhibit the oxygen supply, are continually added to the pile. Consequently, the lag period in tailings is likely to be longer than in siliceous waste rock because the average tailings ANP (225 t/1,000 t) is greater than the ANP of siliceous waste rock (162 t/1,000 t), because of the slower intrinsic rate of oxidation observed in tailings kinetic tests, and because the oxygen supply is expected to be slower in tailings than in waste rock. It may be that the average lag period (before generation of acidic pH levels) for the operating tailings facility is in the range of 20 to 50 years. Proposed reclamation and closure methods were designed to slow or stop the weathering process so that acidification does not occur in the facility after closure (USEL 1998).

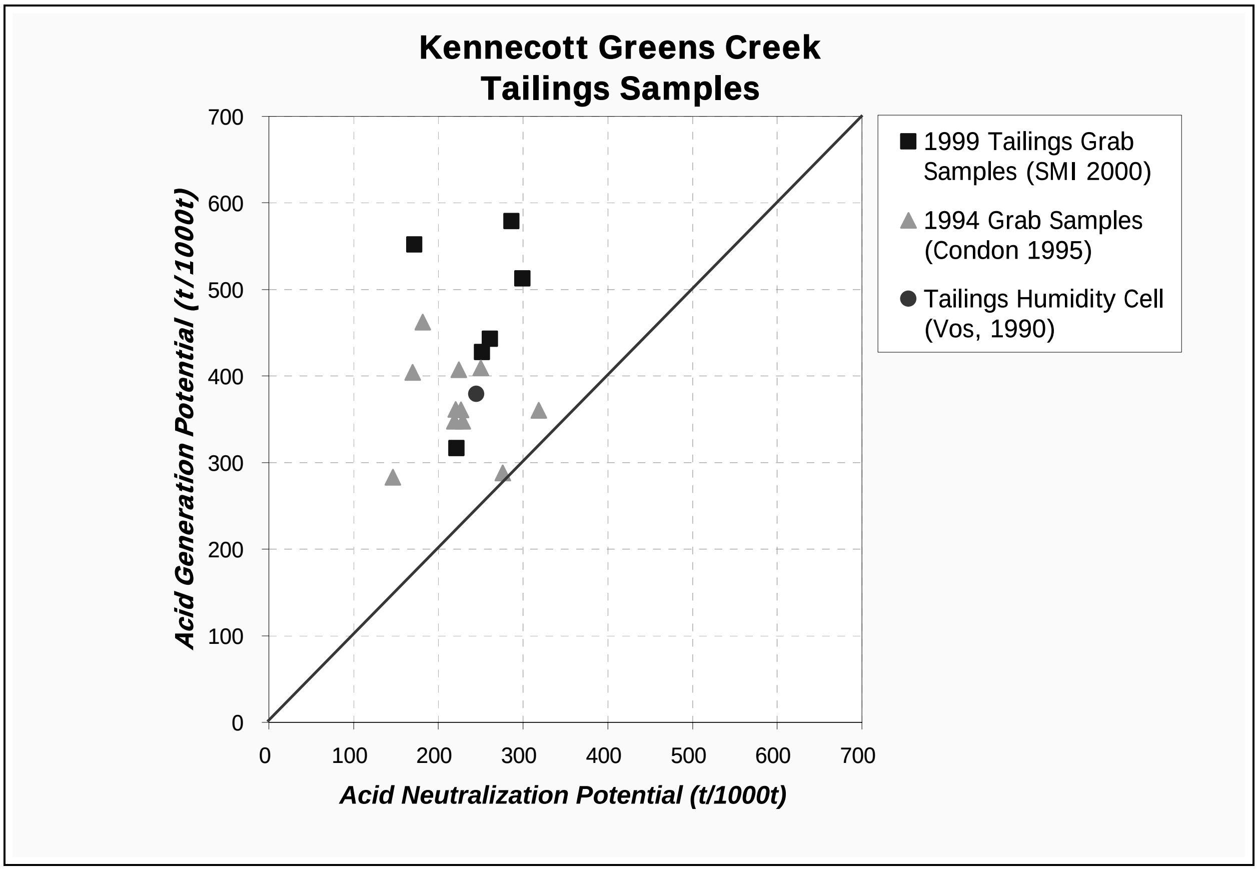

Figure 8. Net neutralization potential of various 1999 grab samples collected from the Greens Creek Mine facilities compared to analysis of 1994 grab samples from KGCMC 1995.

<u>Geochemical Test Results – Contact Water pH -</u> Monitoring of the pH of water that has contacted tailings at Greens Creek (Figure 9) and in grab samples of tailings collected at various times during operations (Figure 10) indicates that the carbonate minerals have uniformly maintained an alkaline pH throughout the operation of the facility.

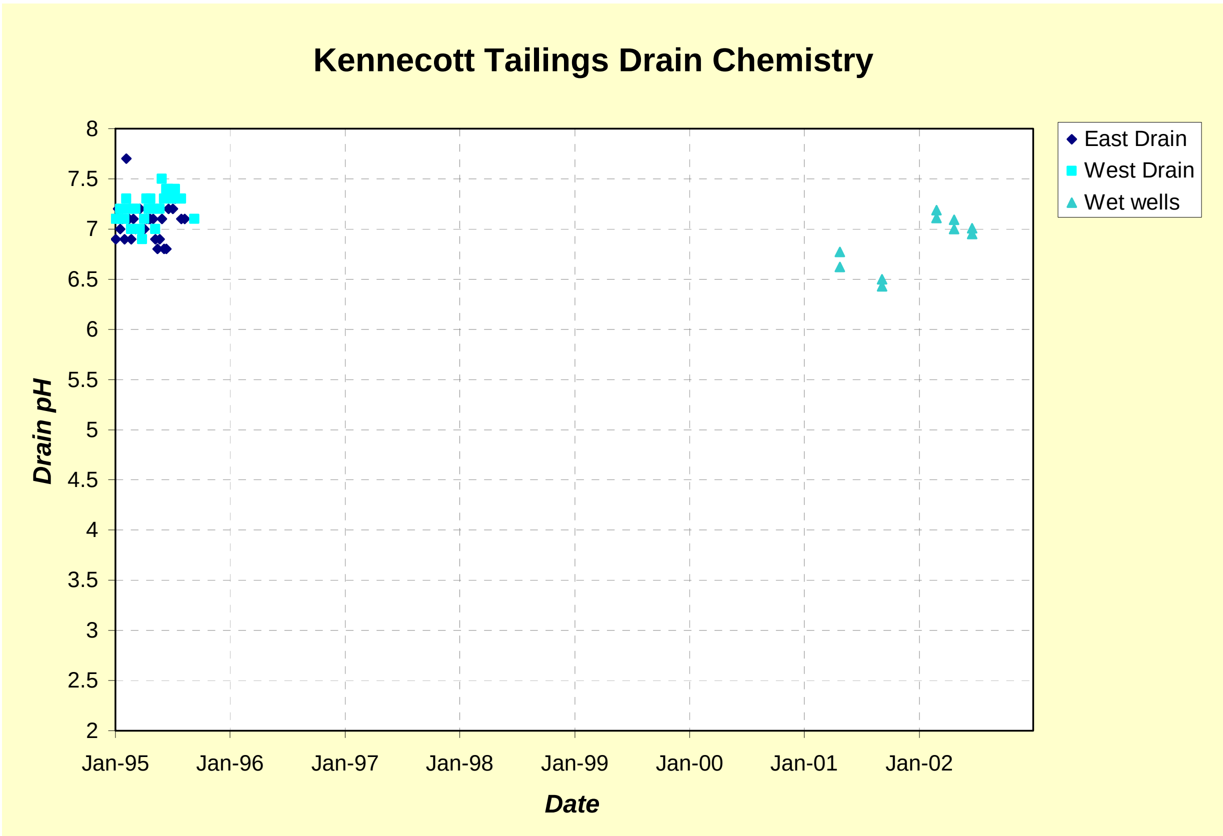

Figure 9. Measured pH in drains and wet wells.

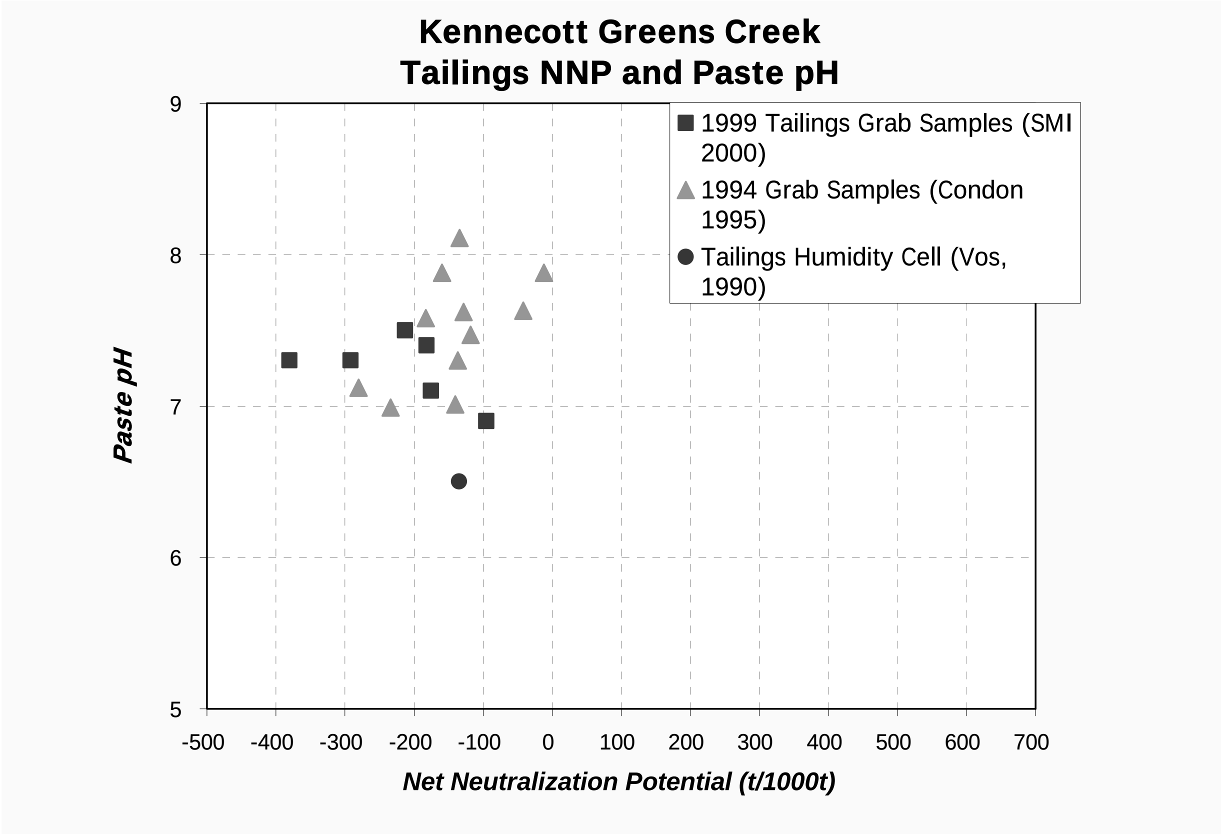

Figure 10. Paste pH and net neutralization potential of various 1999 grab samples collected from the Greens Creek Mine facilities.

Geochemical Test Results – Shake Flask Tests and ANP Consumption – Tailings samples were collected and analyzed by KGCMC in 1995 (KGCMC (1995). Two kinds of geochemical tests conducted by KGCMC (static tests and shake flask tests) provided relevant data pertaining to the lag period prior to onset of acidification. In the shake flask samples, the older, well-oxidized samples produced the least alkalinity, which may indicate that much of the calcite in the older samples had been consumed leaving less soluble dolomite accounting for the lower alkalinity. If all calcite and dolomite in the oxidized tailings are eventually consumed, and the alkalinity production decreases to zero, the system will no longer be buffered and pH will drop rapidly. Comparison of shake flask tests showed that in the time the tailings were exposed (2-5 years), alkalinity decreased from about 46 mg/l CaCO3 (average of relatively unoxidized samples) to 13 mg/l CaCO3, which represents 72% reduction.

The NNP levels of oxidized tailings samples did not decrease by as large a percentage as did the alkalinity. Therefore the measured alkalinity in the shake flask tests may not correlate directly with the reduction in the carbonate content of the tailings. Relying on the ABA tests for sample 2201835 (which exhibited 72 % reduction in alkalinity in shake flask tests), it would appear that 39 % of the neutralization capacity was consumed in 2-5 years. Given the uncertainty regarding the length of exposure, and assuming there is a measurable rate of oxidation, the entire neutralization potential could be consumed within 5 to 12 years in this sample. Similarly, samples collected in 2000 showed 67 % of the original ANP levels after 6 years and 87 % after 8 years. Assuming a linear decrease in ANP levels, these samples indicate a lag period of 18 and 62 years respectively. These results, though variable, are in general agreement with the predicted lag period of 20 to 50 years described above.

2.6.2 Long-term Acidification Potential

The long-term acidification potential is primarily dependent on the amount and reactivity of sulfides contained in tailings, the amount and reactivity of carbonate minerals, and on the oxygen supply. Review of historic geochemical testing of Greens Creek tailings and waste rock suggests that the lag period prior to development of acidic conditions may be in the range of 20 to 50 years. The likely timing of tailings acidification in the Kennecott tailings facility was independently estimated based on the intrinsic rate of sulfide oxidation that would exist at various times after tailings placement, which included determining the estimated oxygen flux into the tailings after closure. The intrinsic rate of sulfide oxidation is the amount of remaining sulfide that oxidizes each year and is expressed as percent per year. The resultant change in sulfide content through time follows first-order kinetics, which fits some of the available experimental data (Evangelou 1995). When oxygen is abundant (such as in a humidity cell test), the characteristics of the pyrite crystal lattice and other solution phase factors constrain the oxidation rate. When the oxygen flux is low (such as occurs after closure), the availability of oxygen becomes rate-limiting.

Intrinsic Rate of Pyrite Oxidation in Kinetic Tests – Vos (1990) conducted both humidity cell and column tests on a sample of Kennecott tailings containing 12.1 % sulfide sulfur. The rate of release of sulfate decreased through time in both tests, as would be expected for two reasons: 1) during the early stages of a test sulfate may be released because of dissolution of sulfate minerals such as gypsum that formed as a result of previous oxidation, and 2) most conceptual models of sulfide oxidation (such as the “shrinking core” model Davis and Ritchie 19) would predict decreasing sulfate through time.

After 6 months, the 10 week average rate of sulfate release was 374 mg/kg/week, which equates to an intrinsic oxidation rate (IOR) of 5.3 % per year. The kinetic column test operated by Vos released 37 mg/kg/week after 6 months, for an IOR of 1.6% per year. At the end of the 1.5 year humidity cell test, the rate of sulfate release had decreased to 25 mg/kg/week, so that the IOR was 0.3 % /year.

Oxygen Flux and Depth of Oxidation - The rate of oxygen flux into the tailings after closure will be reduced by construction of an engineered cover. The rate of oxygen diffusion through soil covers are inversely correlated with the residual water content of the soil layers. The diffusivity of a soil layer can be predicted on the basis of the soil tortuosity (Jury et al. 1991 equation [2]).

$$D_s = D_{air} \times \varepsilon_{soil},$$

$$where\, \varepsilon_{soil} = \frac{\alpha^{\left(\frac{10}{3}\right)}}{\phi^2}, \qquad [2]$$

α *is the volumetric air content, and* ϕ *is the porosity*

When the soil cover consists of different soil materials, the overall diffusivity can be estimated by computing the harmonic mean diffusivity (Aubertin et al. 1999). Using the material properties from the USEL (1998) report, the oxygen diffusion into tailings was predicted for varying residual water content of tailings (Table 6). The estimated flux varied from 4.23 to 4.08 g/m^2/yr for residual water content of 70 to 85%. Additionally, infiltrating water contains up to 10 mg/L dissolved oxygen, which may add up to 1.09 g per year of oxygen flux. The predicted combined oxygen flux from gaseous diffusion and advection of dissolved oxygen in water agreed closely with the 5 g/m^2/yr oxygen flux predicted by O'Kane (2001) using the SoilCover© model.

A diffusive model based on the Davis-Ritchie Approximate Analytical Solution (Davis and Ritchie 1986) was used to predict the depth of oxygen penetration through the engineered cover layer (Figure 11). Using appropriate values for pyrite content and diffusivity, the depth of oxygen penetration was expected to be only 25 to 30 cm after 500 to 1,000 years. Given the oxygen penetration and oxygen flux, the IOR can be calculated to be 0.0057 % per year for the period after cover placement when oxygen availability will limit pyrite oxidation.

Table 6. Calculated harmonic mean diffusivity of the engineered soil cover at varying degrees of tailings saturation.

Oxygen Flux after cover placement in the Kennecott Tailings facility.

Material	**Thickness in**	**Thickness m**	**Porosity**	**Volumetric Water (%)**	**Relative Saturation**	**Tortusosity M-Q**	**Dei**
loose till	24.00	0.6096	50%	35%	70.0%	0.007	1.08E-07
capillary break	8.00	0.2032	50%	10%	20.0%	0.189	2.83E-06
compact till	24.00	0.6096	50%	48%	95.0%	0.000	2.74E-10
capillary break	8.00	0.2032	50%	10%	20.0%	0.189	2.83E-06
tailings	40.00	1.016				(see below)	
	104.00	2.64					

Tailings relative saturation (%)	85%	80%	75%	70%
Tortuosity (M-Q)	7.31E-04	2.15E-03	5.16E-03	1.09E-02
Tailings Diffusivity (m^2/s)	1.10E-08	3.23E-08	7.74E-08	1.63E-07
Harmonic mean Diffusivity (m2/s)	1.14E-09	1.17E-09	1.18E-09	1.18E-09
Oxygen Flux ($g/m^2/yr$)	4.08	4.19	4.22	4.23

Assumptions

Co (kg/m^3)	0.3
Ci (kg/m^3)	0
D of Oxygen in Air (m^2/s)	1.50E-05
sec/yr	31,557,600
Tortuosity = a^10/3/n2, a = volumetric air content, n = porosity	
Tailings porosity	40%

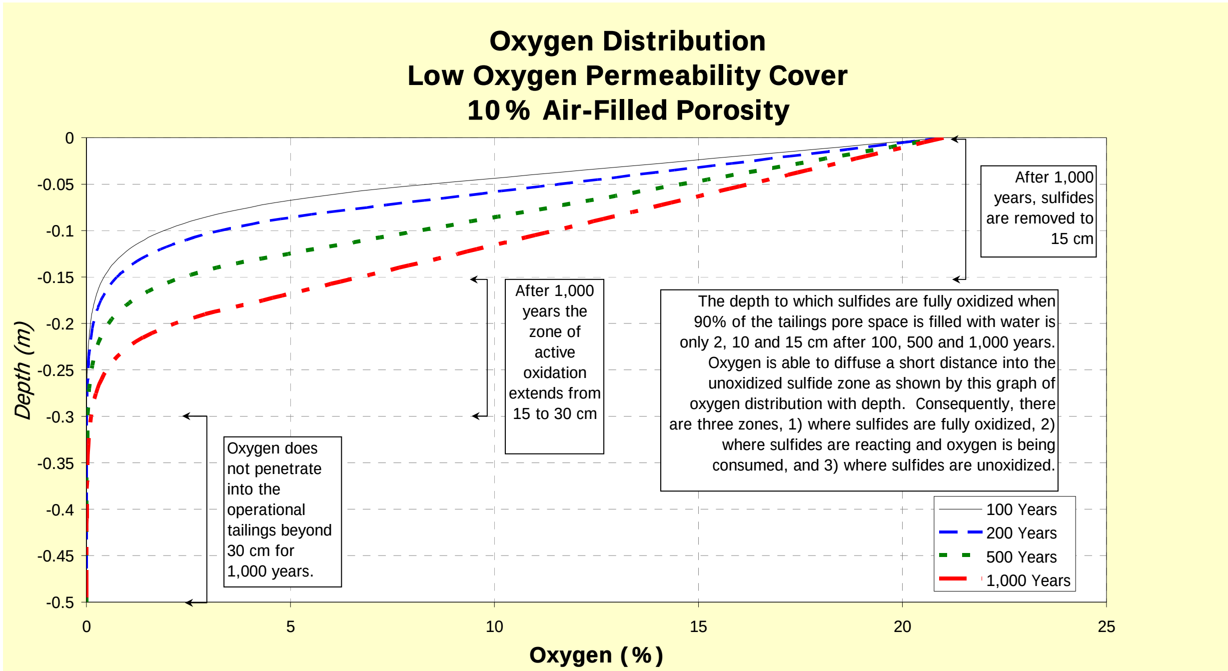

Figure 11. Predicted depth of oxygen penetration into the tailings after placement of the engineered soil cover.

<u>**Predicting long-term change in ANP and AGP from Intrinsic Oxidation Rate**</u> - The IOR values derived for initial tailings placement (0- 3 years, IOR = 5%), the remainder of the operating period (3 to 25 years, IOR = 0.3 %), and after placement of the engineered cover (>25 years, IOR – 0.01 %) were used to calculate the changes in ANP and AGP that would occur in the tailings (Figure 12). Localized acidification would be expected to occur when all of the ANP was exhausted or nearly exhausted in a portion of the tailings material. This analysis predicts that during the operating period, the ANP would be fully dissolved in a portion of the tailings after about 25 years, which is consistent with the lag period predicted from kinetic tests. Initial occurrence of acidity would likely be confined to a thin upper veneer of material, and would not be expected to change the pH of tailings seepage. More complete consumption of ANP in a thick zone of tailings would be required for the pH of tailings seepage to be affected. The analysis of the kinetics of pyrite oxidation in the Kennecott tailings suggests that enough ANP will be retained even in the surficial tailings to maintain neutral pH for hundreds of years after closure. Consequently, the tailings acidification risk is considered minimal. However, the data upon which this analysis is based are variable, and the underlying assumptions have a high degree of uncertainty making this estimate subject to error. Although the model of tailings geochemistry assumes that acidification will not occur, a monitoring program is in place (KGCMC 2000) to identify incipient acidic conditions in the tailings facility and develop appropriate mitigation measures. Since acidification, if it occurs, is expected to occur near the surface of the tailings, surface application and incorporation of lime, limestone, or lime-stabilized sewage sludge should provide an effective acid control strategy. Kennecott has successfully used

alkaline amendments and various polymers at Greens Creek (Condon 1999) as a means of slowing acid generation and metals release in potentially acid generating waste rock.

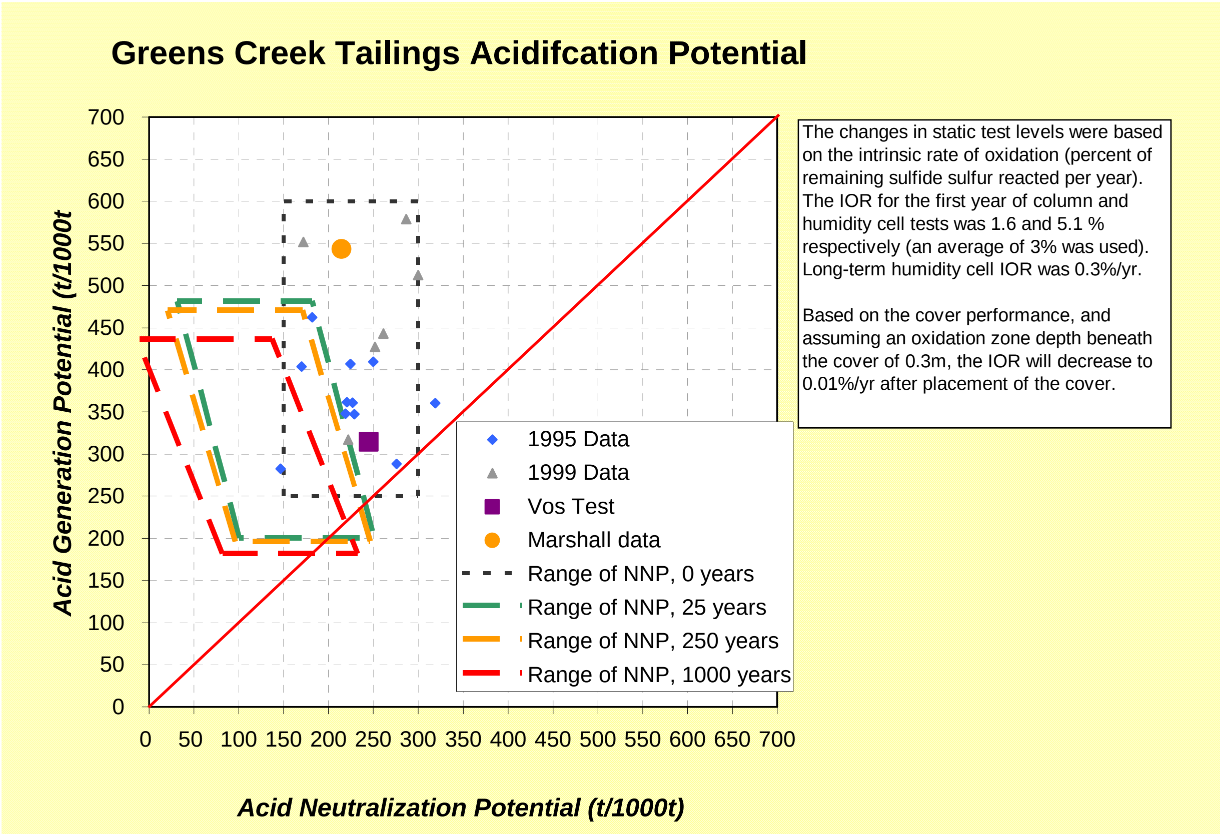

Figure 12. Predicted temporal change in the range of ANP and AGP values in tailings.

2.6.3 Tailings Metal Leaching Risk

At the neutral pH conditions that are expected to prevail for at least tens of years in Greens Creek tailings, oxidation of tailings may cause some metals contained in the tailings to become soluble. Zinc, for example, is partially soluble even when the pH is alkaline as in the Greens Creek tailings pile. Consequently, water leaching through or running off of the tailings pile may contain elevated zinc. This is why the Greens Creek tailings facility has been designed to minimize contact with water. All contact water at the facility is collected and treated in a water treatment facility to remove zinc and other metals.

<u>**Historic Tailings Water Quality-**</u> Historical evaluations of tailings contact water centered on two aspects, the potential for tailings to become acidic and the quantity of soluble metals that may be released to contact waters. The ARD risk of tailings, described in the previous section, was found to be low for hundreds of years due to the abundance of carbonate minerals. Consequently, soluble metals such as zinc are the primary geochemical concern associated with contact water. Historic

testing (Figure 13) suggests that when tailings are exposed to oxidation, the zinc concentration in contact water increases even though the pH remains in the neutral range (6.7 to 8.0). Typical zinc concentrations in tailings contact water ranged from 1 to 50 mg/L in shaker batch tests (Condon 1995). Similar zinc concentrations were found in 1995 in tailings drain water that consisted of tailings seepage and surface runoff (Condon, Pers Comm 2002). When tailings are first milled, most of the remaining zinc may be in a sulfide form, which is insoluble. Oxidation of zinc sulfide makes the zinc soluble, and the liberated zinc remains dissolved unless the concentration becomes high enough for secondary zinc hydroxide or zinc silicate sulfate minerals to precipitate.

Humidity cell tests conducted on tailings by Vos (1990) showed what may occur if tailings become acidic. The tailings humidity cell and column test produced low pH solutions for the initial weeks of testing. The solutions became neutral in later stages of testing after oxidation products were rinsed from the sample. It is likely that oxidation of the tailings that occurred prior to testing caused acid sulfate salts to form that coated the carbonate minerals and reduced their ability to neutralize acidity. The resulting soluble zinc concentrations were greater than 100 mg/L when the pH was in the range of 3.5 to 4.5. This acidification process is not expected to occur in tailings in the field because runoff and infiltration prevents acid salt accumulation. After placement of the engineered soil cover, the reduced supply of oxygen will slow sulfide oxidation thereby controlling salt accumulation.

Recent analysis of tailings waters contained in the geochemistry baseline report (Figure 14 and EDE 2002) shows that zinc concentrations are generally lower than levels found in historic tests (Figure 13). This may result from improvements in tailings compaction that reduces the rate of oxidation. Process water comprises the interstitial water contained in freshly placed tailings. Oxidation within the unsaturated zone causes zinc concentration to increase to 1 to 20 mg/L with the pH remaining in the range of 6.5 to 7.5. This may also be true for water situated in the unsaturated zones of the drainage system (Condon, Pers Comm, 2002). Zinc concentrations in the saturated zone of the tailings are much lower than in either the runoff or unsaturated zone. The hydrologic and geochemical processes that occur within the tailings are described in more detail in the following section.

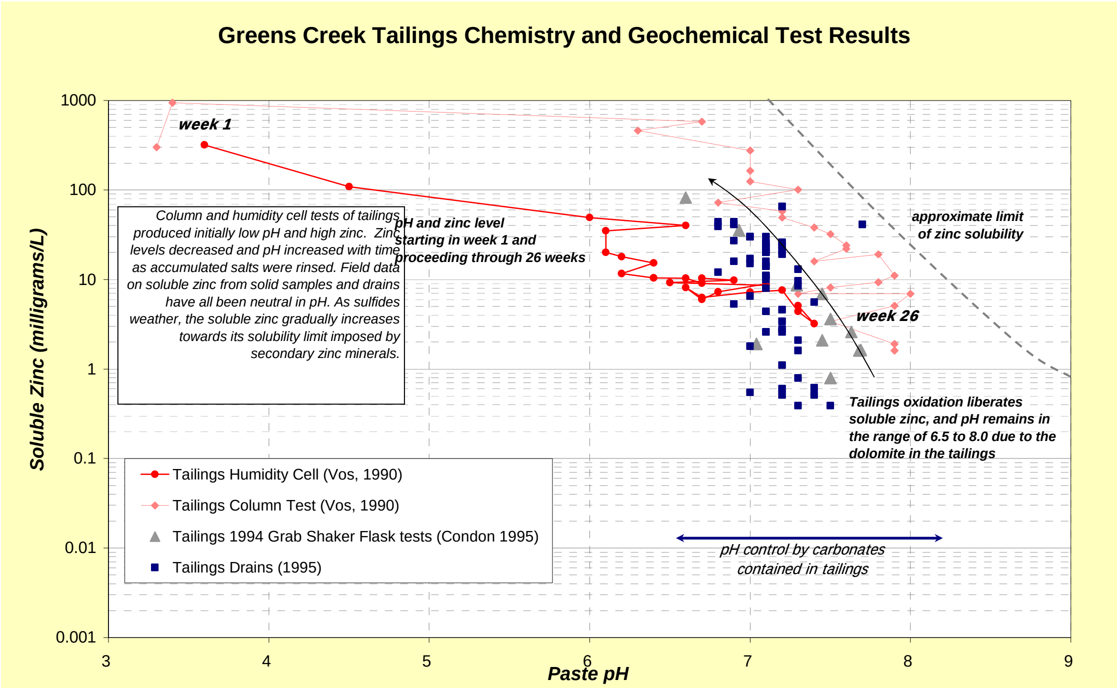

Figure 13. Historic data on zinc solubility and pH of tailings contact water.

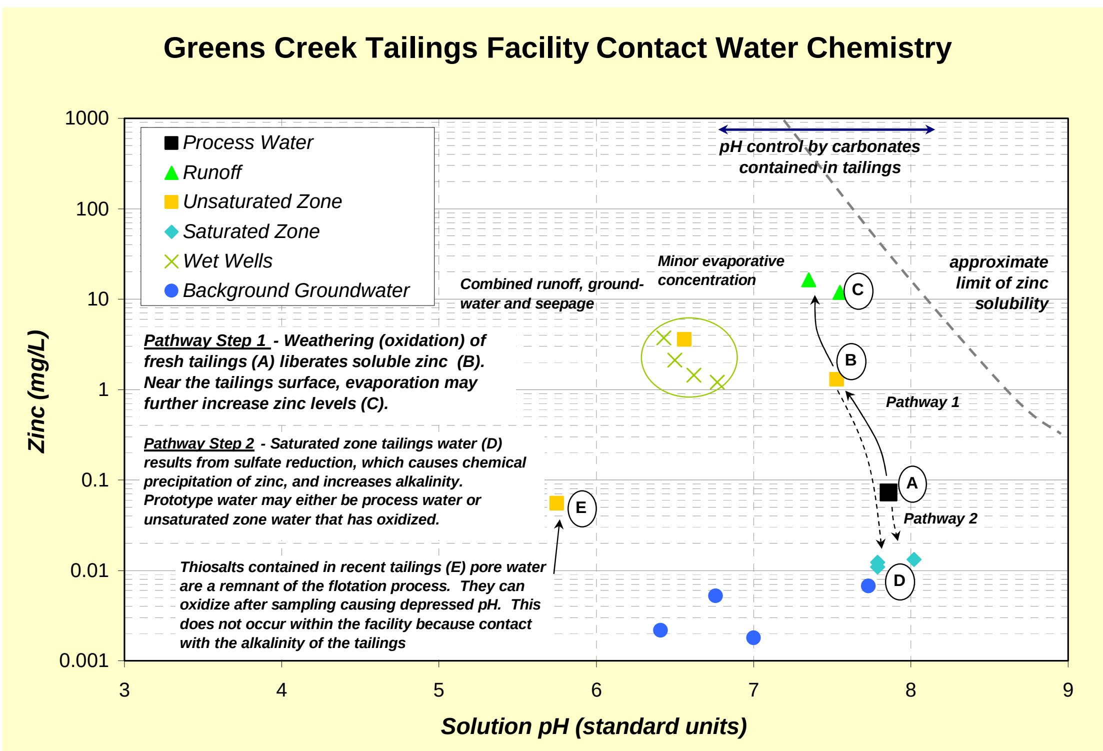

Figure 14. Data from baseline reports on tailings contact water chemistry.

2.6.4 Geochemistry of Contact Water

The quality of water contained in pore spaces within the tailings undergoes a complex evolution during mining and post-closure. When tailings are initially placed, the associated pore water is residual process water. Process water is strongly alkaline and contains low levels of dissolved metals and sulfate. During mine operation, the surficial layer of tailings undergoes oxidation. Though the pore water is expected to remain neutral in pH, the sulfate and dissolved zinc levels may rise as a result of oxidation (Figure 14). As sulfate and zinc accumulates, some secondary minerals containing these constituents may precipitate from solution, creating a reservoir of secondary salts that may be leached during the post-closure period when oxidation is expected to slow because of cover placement.

As meteoric water enters the tailings, the process water originally contained in the tailings will be displaced by water that is representative of the chemical oxidation of the tailings (refer to the lysimeter samples in Table 7 for representative water quality of shallow tailings water). As the shallow tailings water (with neutral pH, elevated sulfate and zinc) moves downward it may encounter geochemical conditions that differ from those in the shallow portion of the pile. For example, the redox potential and dissolved oxygen may decrease as water moves downward resulting in the chemical reduction of sulfate to sulfide and resultant precipitation of secondary zinc sulfide [3] (Dvorak et al. 1992). Consequently, if geochemical conditions are different in the deepest part of the pile than in the shallower zones, the water quality of the tailings water may also differ.

$$SO_4^{-2} + 2\ CH_2O = H_2S + 2\ HCO_3^{-} \qquad [3]$$

Additionally, the rate of tailings oxidation, and the thickness of the oxidized zone should decrease after placement of the soil cover that is designed to minimize oxygen flux. Subsequent to the cover deployment, the sulfate and zinc concentrations in tailings water within the oxidized zone may decrease unless a reservoir of secondary salts are present that slowly dissolve and maintain elevated sulfate and zinc levels. As a result of these processes, prediction of the quality of water draining from the pile post-closure will require an understanding and simulation of geochemical processes within the pile interior. These geochemical processes are best illustrated by reviewing the chemical composition of contact waters collected from various location within the tailings facility.

Geochemical Processes Occurring in Tailings Facility: The geochemical processes that occur within the tailings facility can be inferred from the chemical composition of contact water and from the characteristics of tailings material. It is important to understand these processes because they are likely to occur in the future, but at relative rates that may change depending on how the tailings facility is reclaimed. Geochemical and hydrologic processes, as modified through facility reclamation, will determine the post-closure quality of contact water.

Process water- The chemistry of process water is the starting point from which contact water chemistry evolves. Fresh tailings contain 26 to 30 percent process water (Table 7) by volume. Process water has a neutral pH, and is dominated by calcium and sulfate ions. Process water also contains thiosalts such as thiosulfate ($S_2O_3^{-2}$) and trithionate ($S_3O_6^{-2}$) that oxidize over a period of hours to days after exposure to oxygen. Oxidation of these ions produces acidity and forms sulfate. When thiosalt oxidation occurs within the tailings, the acidity is neutralized by the dissolution of dolomite. Consequently, calcium, magnesium, and sulfate concentrations will all increase from levels found in process water (Figure 14). Thiosalt oxidation may not significantly affect zinc concentration because the sulfides themselves are not reacting and acidity is rapidly neutralized. When interstitial solution was extracted from fresh tailings (Figure 14 – label E), thiosalt oxidation caused the pH to drop to 5.75 because the extracted solution was not in contact with the dolomite minerals in the tailings when the oxidation occurred. The acidification resulting from thiosalt oxidation may occur in runoff water but will not occur in solution that remains in contact with the tailings.

Water originally held in the pore space of tailings gradually changes in two ways. First, oxidation of thiosalts and sulfides causes dolomite to be dissolved and soluble magnesium and sulfate to accumulate. Increases in soluble zinc may also accompany these changes. Additionally, the process water is pushed downward into the tailings as meteoric water infiltrates into the pile. Assuming that the net infiltration rate into the pile is 6.5 inches per year (EDE 2002), and infiltration occurs uniformly, the rate of displacement of process water (at a residual water content of 30 %) is 21.7 inches per year. It would require at least 50 years to displace all process water from the thickest part of the existing pile (75 feet), and would take longer for the expansion. The process water will be displaced faster in thinner parts of the tailings.

Unsaturated Zone Water- The chemical evolution of water in the unsaturated zone (Table 7) is illustrated in Figure 14, which shows a trend in contact waters to increase in zinc and other metals while maintaining a neutral pH. This water chemistry may also be representative of water in the unsaturated zone of the drain system. The increase in zinc is due to the oxidation of zinc sulfides such as sphalerite, which release zinc into more soluble forms. Neutral pH is maintained despite the oxidation of pyrite because of the dissolution of dolomite. At the neutral pH of the pore water, many metals are only modestly soluble and may precipitate in the form of secondary oxide or sulfate minerals. The water sample from the lysimeter installed in the old tailings is not representative of unsaturated zone water. A PVC cover was installed over this portion of the old tailings causing evaporative salts to accumulate near the tailings surface.

Tailings Runoff- The chemistry of runoff (Table 7 and Figure 14) results from similar oxidation processes as occur in the unsaturated zone. Consequently, the chemistry of runoff is similar to that found in the unsaturated zone, except that runoff is somewhat higher in zinc. This may result from the release of zinc from argillite exposed in causeways at the surface, which contains abundant zinc and weathers rapidly.

Tailings Saturated Zone- Saturated zone water (Table 7 and Figure 14) contains higher sulfate (up to 2000 mg/L) than process water (660 mg/L) indicating that thiosalt or sulfide oxidation or both has occurred. The zinc concentrations in the saturated zone, however, are lower than in process water, and are much lower than in either the unsaturated zone or in runoff. The lower zinc levels are attributed to a process known as sulfate reduction. Organic compounds are added to the tailings from various sources including flotation reagents and wastewater biosolids from the Cannery housing facility. Certain microorganisms that degrade these organic compounds under anaerobic conditions reduce sulfate to sulfide and produce bicarbonate. Some of the sulfide ions form an insoluble precipitate with many metal ions, especially iron, zinc, nickel and cadmium. Sulfide levels of 0.06 to 13 mg/L were detected in saturated zone waters in the tailings. Additional laboratory and field tests on samples obtained from the deep tailings (Appendix 3) also showed similar chemical trends (e.g. reduced levels of zinc and nickel and detectable sulfide in all but one sample). It is not clear whether the prototype water in the saturated zone is the process water originally contained with the tailings or represents meteoric water that was once chemically similar to the unsaturated zone water. Regardless of the source of the saturated zone water, it is appropriate to assume that the water oxidized sometime after the tailings were placed (as evidenced by the elevated magnesium and sulfate levels), that the zinc levels were once in the range of 1 to 3 mg/L due to the sulfide oxidation, and that zinc levels were subsequently reduced to 0.11 to 0.13 mg/L because of sulfate reduction.

Table 7. Representative chemistry of contact water in the Kennecott tailings facility.

Parameter		Process Water	Wet Wells				Tailings Saturated Zone			Tailings Unsaturated Zone		
Concentration	Units		Wetwell 2	Wetwell 2	Wetwell 3	Wetwell 3	PZ-T-00-1	PZ-T-00-3	MW-TB2	SW01-01	TSS99-01	TSS99-03
			Main Pile	Main Pile	West Buttress	West Buttress				New Tails	New Tails	Old Under PVC
		Process Water	underdrain	underdrain	underdrain	underdrain	tailings	tailings	tailings	Suction Lysimeters (tailings)		
		6/14/2001	4/25/2001	9/7/2001	4/25/2001	9/7/2001	5/9/2001	5/9/2001	4/25/2001	7/5/2001	12/7/1999	11/17/1999
Total Alkalinity	mg/l $CaCO_3$	<5.0	262	252	404	227	290	340	357	<5.0	38	491
Hardness	mg/l	999	1110	1350	2230	1710	2750	2320	1760	3530	NA	
Lab Spec. Cond.	uS/cm	1,860	1,790	2,050	3,350	2,570	3,380	3,240	3,240	5,290	7,560	14000
Lab pH	s.u.	7.86	6.77	6.5	6.62	6.43	8.02	7.79	7.79	5.75	6.56	7.53
Arsenic	mg/l, dissolved	0.0477	0.0191	0.0212	0.00426	0.00506	0.0108	0.0114	0.0168	0.0341	<0.01	<0.005
Barium	mg/l, dissolved	0.0453	0.0252	0.0319	0.021	0.0235	0.0129	0.0136	0.0117	0.0386	NA	
Cadmium	mg/l, dissolved	<0.001	<0.0001	<0.001	0.00084	0.00743	<0.0001	<0.0001	<0.0001	0.0017	0.00376	<0.005
Chromium	mg/l, dissolved	<0.001	<0.0005	0.00137	0.00092	0.00147	<0.0005	<0.0005	0.00097	0.00134	NA	
Copper	mg/l, dissolved	<0.002	0.00104	0.00216	0.00292	0.00374	0.00578	0.00576	0.00309	0.274	1.32	0.0482
Lead	mg/l, dissolved	0.123	<0.0002	0.00143	<0.0002	0.005	<0.0002	<0.0002	<0.0002	0.00216	16.9	<0.005
Mercury	mg/l, dissolved	<0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.000055	NA	
Nickel	mg/l, dissolved	0.00309	0.054	0.122	0.0591	0.2	0.00159	0.00185	0.00151	0.00712	0.048	0.00749
Selenium	mg/l, dissolved	0.274	0.00188	0.00244	0.00335	0.00747	0.00362	0.00253	0.00134	0.145	**0.244**	**0.0137**
Silver	mg/l, dissolved	0.00464	<0.0001	<0.001	<0.0001	<0.001	0.00013	0.00015	<0.0001	0.353	NA	
Sulfate	mg/l	660	840	1130	2070	1580	1980	1790	1820	2410	2290	17000
Zinc	mg/l, dissolved	0.0727	1.2	2.11	1.45	3.71	0.0132	0.0123	0.0109	0.0552	3.57	1.29
Sulfide	mg/l	<0.05	<0.05	NA	<0.05		13	0.0625	7.0	<0.05	NA	

Table 7 (continued).

Parameter		Process Water	Wet Wells				Tailings Saturated Zone			Tailings Unsaturated Zone		
Concentration	Units		Wetwell 2	Wetwell 2	Wetwell 3	Wetwell 3	PZ-T-00-1	PZ-T-00-3	MW-TB2	SW01-01	TSS99-01	TSS99-03
			Main Pile	Main Pile	West Buttress	West Buttress				New Tails	New Tails	Old Under PVC
		Process Water	underdrain	underdrain	underdrain	underdrain	tailings	tailings	tailings	Suction Lysimeters (tailings)		
		6/14/2001	4/25/2001	9/7/2001	4/25/2001	9/7/2001	5/9/2001	5/9/2001	4/25/2001	7/5/2001	12/7/1999	11/17/1999
Aluminum	mg/l, dissolved	0.492	0.316	0.288	0.307	0.33	0.364	0.263	0.287	1.69		
Boron	mg/l, dissolved	0.25	0.123	<0.1	0.118	<0.1	0.224	0.166	0.11	0.48		
Calcium	mg/l, dissolved	386	272	343	443	467	358	225	182	837	**1720**	**489**
Iron	mg/l, dissolved	<0.1	15.5	19.3	15.8	2.35	<0.1	0.15	<0.1	<0.1	0.192	0.195
Magnesium	mg/l, dissolved	8.52	105	121	273	132	373	355	316	349	**453**	**4620**
Sodium	mg/l, dissolved	50.3	25.1	23	49.6	21.9	133	188	129	61.7	**89.4**	**15.5**
Antimony	mg/l, dissolved	0.0148	<0.001	0.00196	<0.001	0.00498	0.00385	0.0129	0.00391	0.0204		
Manganese	mg/l, dissolved	0.00777	3.24	4.82	9.66	4.17	0.453	0.899	0.335	0.0676	1.81	0.269
Molybdenum	mg/l, dissolved	0.15	<0.005	<0.005	<0.005	<0.005	0.00828	0.872	<0.005	0.109		
Potassium	mg/l, dissolved	10.9	9.47	10.5	18.9	10.2	45.5	53.5	43.8	60.2	**66.3**	**29**
Field pH	s.u.	7.86	6.68	6.67	6.56	6.48	8.14	8.15	7.71	7.96	7.12	7.52
Acidity	mg/l $CaCO_3$	507	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	1100	91.7	<10.0
Phosphorus	mg/l	0.224	0.0719	0.0739	0.0759	0.036	0.238	0.159	0.589	0.193	2.44	<2.0
Orthophosphate	mg/l	0.0333	<0.002	0.0288	<0.002	0.00375	0.0487	0.0354	0.00216	<0.002		
DOC	mg/l	23	14.1	<5.0	19.4	<5.0	44	20	33.4	107		
Bicarb Alkalinity	mg/l $CaCO_3$	<5.0	262	252	404	227	290	340	357	<5.0	38	491
Carb Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide Alk.	mg/l $CaCO_3$	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Silica	mg/l	1.14	10.4	9.78	17.8	7.22	10.1	9.15	10.1	<4.0	6.31	5.71
Chloride	mg/l	19.6	9.71	7.47	22.5	7.19	22	35.9	15.8	15.5	13.6	15
Fluoride	mg/l	0.328	0.21	0.272	0.184	0.233	0.375	0.563	0.46	0.317		
Nitrate-N	mg/l as N	13.9	<0.1	0.261	<0.1	1.45	<0.1	0.833	0.25	0.599	21	<1.0
Nitrite-N	mg/l	0.196	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		
Field Spec. Cond.	uS/cm		1691	2220	3090	2160	3660	3510	2950	5020	8363	14310
TDS	mg/l	1500	1500	1900	3200	2600	3100	2800	2700	5400		
TSS	mg/l	16	25	22	34	<4.0	<4.0	<4.0	80	<4.0		
Cat/Anion Bal	% Difference	37.7	16.7	10.47	0.22	0.32	19.2	17.49	1.84	38.6		
Field Temp	C		7.1	12.2	7.8	13	8.1	6.3	7	12	8.6	13.5

Wet Well Contact Water- The chemistry of contact water collected in various wet wells within the tailings facility is affected by the proportions of various waters collected by the water management system. The water is comprised of roughly 8 % tailings seepage and equal parts surface runoff and upwelling groundwater collected in the drain system. All contact waters are currently collected and treated prior to discharge at a marine discharge point under jurisdiction of a NPDES discharge permit.

Chemically, the water in the wet wells should be intermediate between oxidized zone water (from runoff and the unsaturated zones of the drain system) and the upwelling groundwater. For common ions and most metals, this appears to be the case (Figure 15 to 17). Bicarbonate, iron, manganese and zinc are exceptions to this generalization (Figure 16). Consequently, there is a source of these ions that reach the wet wells, but are not derived from the oxidized zone within the pile or from upwelling groundwater.

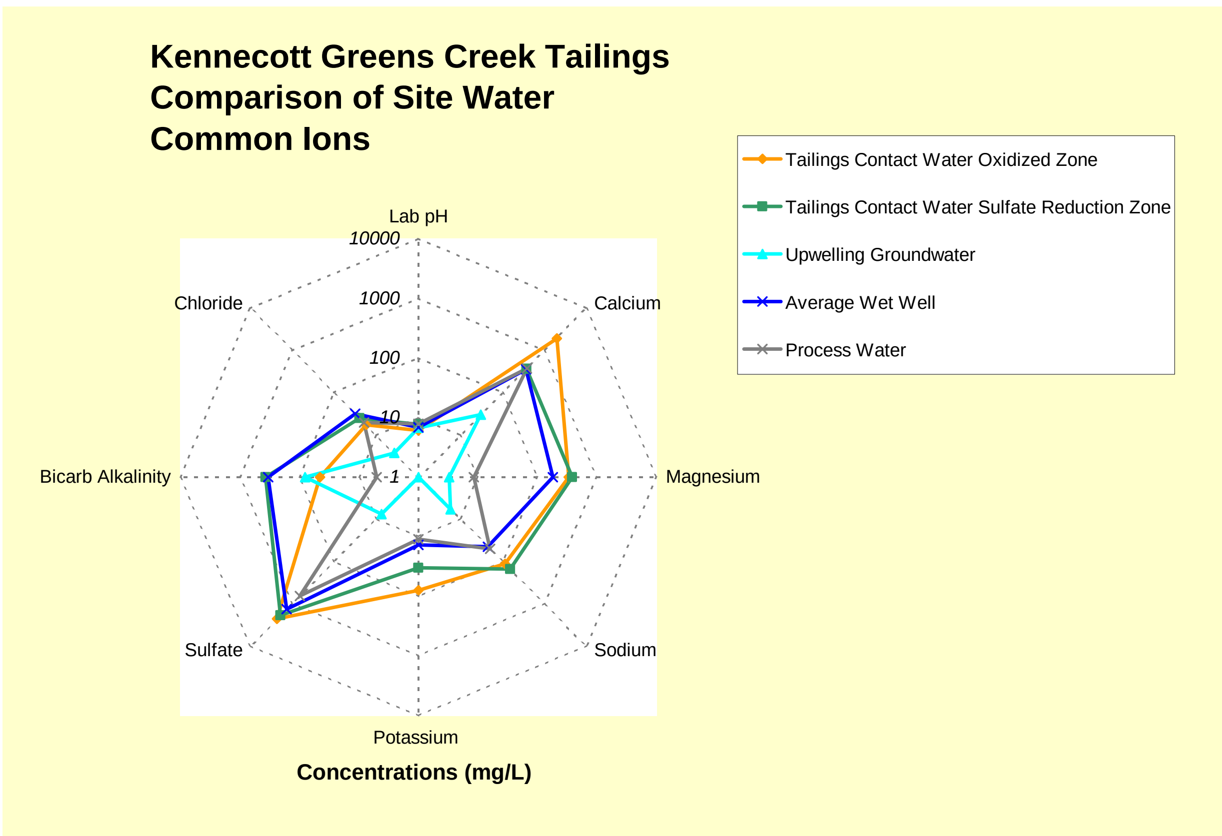

Figure 15. Relative concentrations of common ions in contact waters.

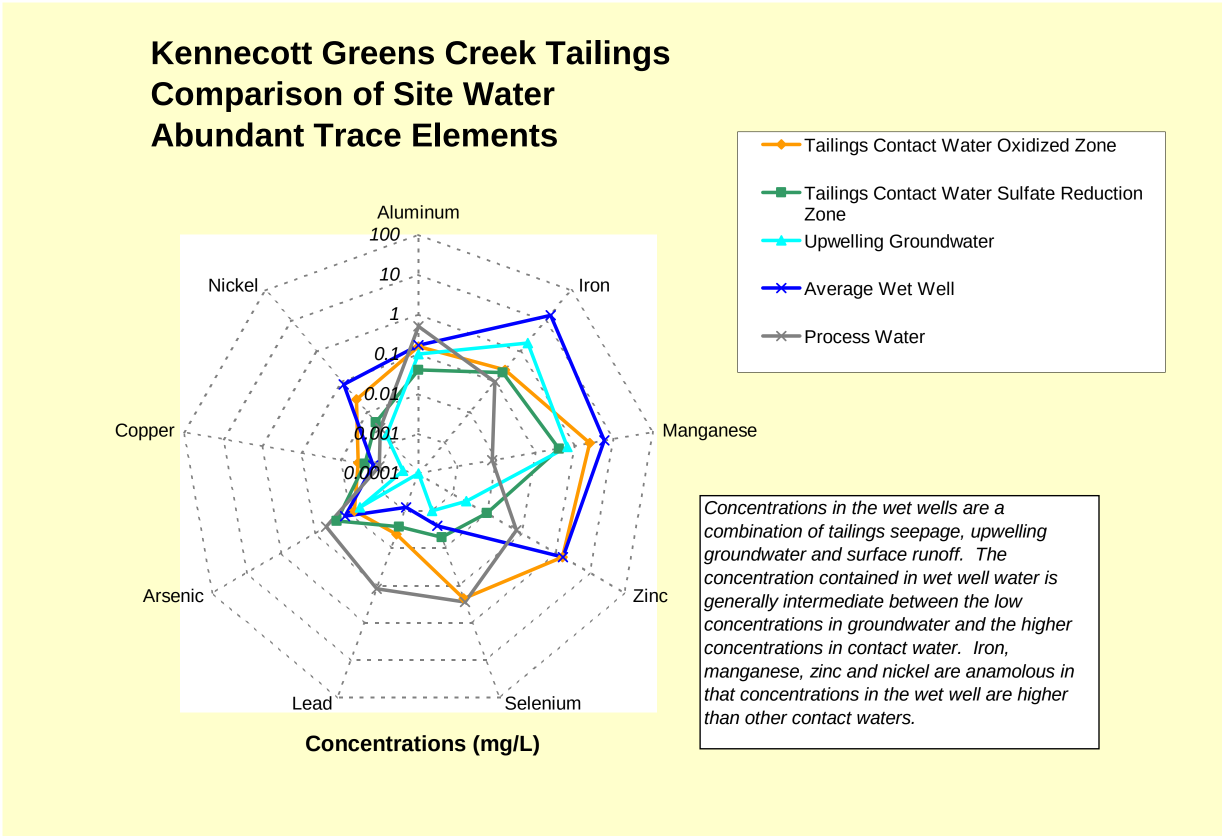

Figure 16. Relative concentrations of trace elements in contact waters.

Excess Bicarbonate is probably derived from the sulfate reduction that occurs in the deeper portions of the tailings facility (equation [3]). Iron and manganese are commonly associated with moderately reducing waters. Reduced forms of iron and manganese are more soluble than their counterparts in oxidized waters. Excess zinc is probably derived from rock material within the drain system. Some of the rock material within the drain is argillite, which is known to release soluble zinc. Currently, portions of the drain system are unsaturated and influenced by atmospheric conditions. Consequently, the argillite in the drain may oxidize and release zinc. Alternatively, some of the tailings seepage reaching the wet wells may contain a higher concentration of zinc than was measured in the oxidized zone of tailings, and may be similar to drain water observed in 1995 (Figure 13).

During baseflow periods when no surface runoff reaches the wet wells, the water should be a mixture of 85 % upwelling groundwater and 15 % tailings seepage. Both upwelling groundwater and saturated zone tailings water are low in zinc, so a low zinc level would be expected during baseflow. The analyses of wet well water at baseflow contain elevated zinc, however, suggesting that either the tailings seepage water is either partly or wholly oxidized water, and/or zinc loads are gained within the drain system. Consequently, sulfate reduction is probably not uniform throughout the entire tailings pile and drain system.

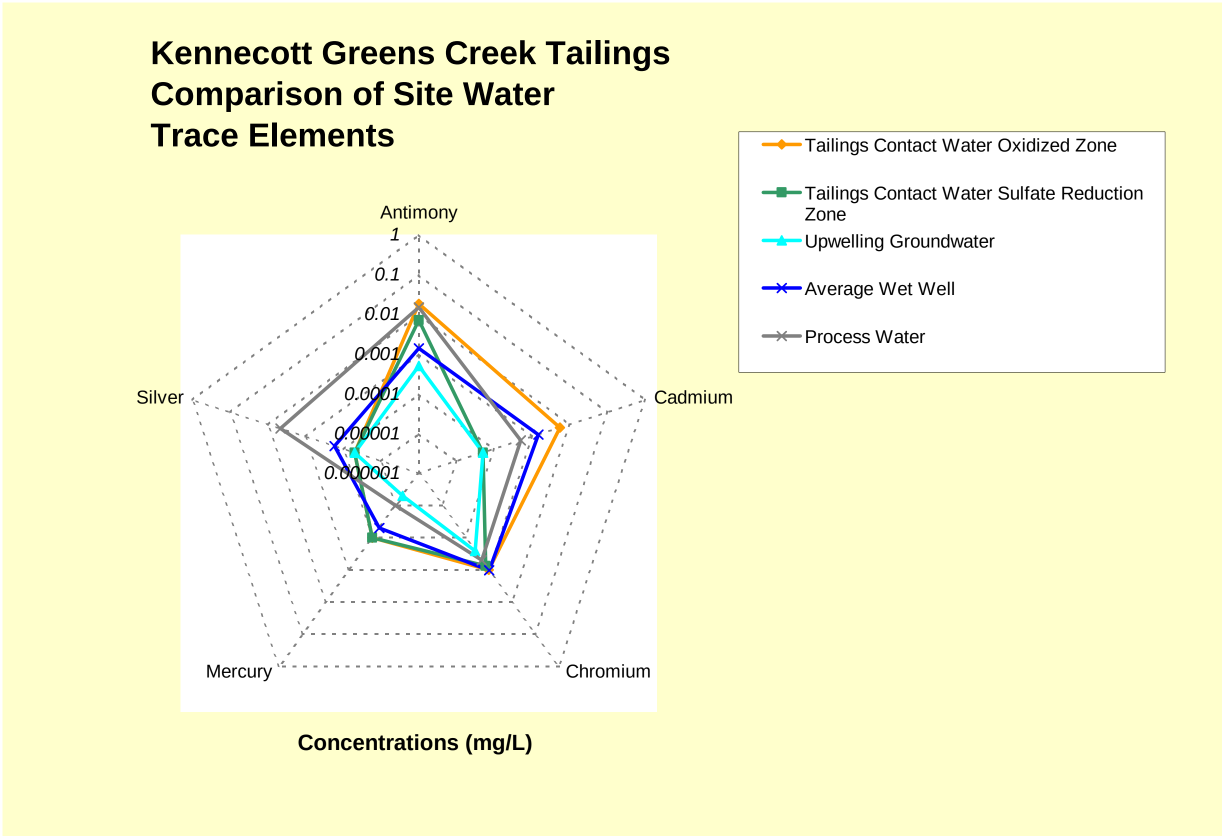

Figure 17. Relative concentrations of less abundant trace metals in contact waters.

3.0 Mass Load Model Development

A mass load model was developed using Microsoft Excel© and Palisade @Risk© to simulate the water quality downgradient of the tailings facility for each of the EIS alternatives. The mass load model was developed in adherence with the spatial, hydrologic, and geochemical conceptual model of the tailings as described in chapter 2.0.

3.1 Key Assumptions and Issues

The purpose of the mass load model is to predict concentrations of metals and common ions within the tailings pore water, in the drain where tailings pore water mixes with upwelling groundwater, in a surface water/groundwater system immediately downgradient of the tailings and in the marine waters of Hawk Inlet. Since concentrations and flows are expected to change through time, the model results are expressed for various points in time after placement of the engineered cover.

Variables such as the amount of rainfall, infiltration coefficient, oxygen diffusion rate, flux of upwelling groundwater, quantity of surface runoff from the pile (which mixes with water flowing out of the drain downgradient of the tailings), and ion concentrations in various waters are used as input for the mass load model. There are two ways of providing model input. Input for **deterministic** models consist of a single numeric value that represents an expected value, an average, or a "best professional judgment" value. In a **stochastic** model such as was used for this analysis, model inputs consist of a range or statistical distribution of values. In this way, the effect of variability in key inputs on model predictions can be evaluated. In a stochastic model, the results consist of a range in values that are associated with probability values.

Part of the variability in parameter input originates from uncertainty such as measurement error or confidence limits associated with predictive models (such as the SoilCover© model used to predict infiltration through the engineered cover). Another important source of variability is the actual change in flow rate that occurs from day to day. For example, the flow of upwelling groundwater and surface runoff (each of which help dilute the constituents in the tailings seepage) vary daily and seasonally. As a result, the model is not meant to predict **average** water quality, because water quality will vary from day to day. The range in model results should be interpreted as the possible **range in instantaneous water quality conditions** downgradient of the tailings.

Key assumptions implicit in the model include:

- the flux of upwelling groundwater into the drain is reflected by the wet well baseflow separation analysis in section 2.5.1;

- the various means of capturing water within the tailings facility including slurry walls, finger drains, blanket drains, and the liner system in the expansion area are efficient;

- the geochemical conditions that prevail within the pile post-closure, especially the oxygen and carbon dioxide content in the subsurface pore space, the redox potential, and the thickness of the oxidized zone are consistent with the conceptual model;

- the flux of oxygen into the tailings is controlled by diffusion and the engineered cover performs as described in the USEL (1998) report;

- the flux of water through the cover is as described in the USEL (1998) report;

- the ingress of oxygen through other areas of the tailings (such as drain inlets) are prevented;

- the upwelling of groundwater into the tailings mass occurs only in historic (existing) portions of the pile and will be prevented in the expansion area by the liner system;

- the field capacity of tailings is as described in section 2.4;

- the point of compliance downgradient of the pile at which water quality will be assessed corresponds to the spatial requirements prescribed by the Alaska Solid Waste permit and the Federal NPDES permit.

3.2 Model Structure

3.2.1 Description

The model is semi-empirical, meaning that portions of the model mechanistically simulate physical and chemical processes based on basic principles, and other parts of the model rely on empirical measurements of, for example, water quality. Figure 18 schematically illustrates the model structure.

The model initially calculates for each constituent the water quality in tailings pore water as a function of the pore volumes of water displaced through the tailings. A pore volume equals the quantity of water held within the tailings material at field capacity. According to the conceptual model, the water quality by pore volume will change from its **Initial** water quality, to the **Intermediate** water quality, and the **Long-term** water quality.

The difficulty with using this approach to calculate changes in metal concentration through time is that 1 pore volume corresponds to a few years at the edge of the pile, and many decades in the middle of the pile. The varying thickness of the pile was incorporated into the model by determining the average tailings pore water chemistry at several distinct time periods.

The concentrations of each constituent in the drain system and after mixing with surface and groundwater are determined by mixing the representative waters at their respective flow rates. The flow of interstitial water from the tailings is determined from the tailings area and the infiltration rate. The infiltration rate is modeled to be 12 to 15% of precipitation during operations and from 8 to 12 % after placement of the engineered cover.

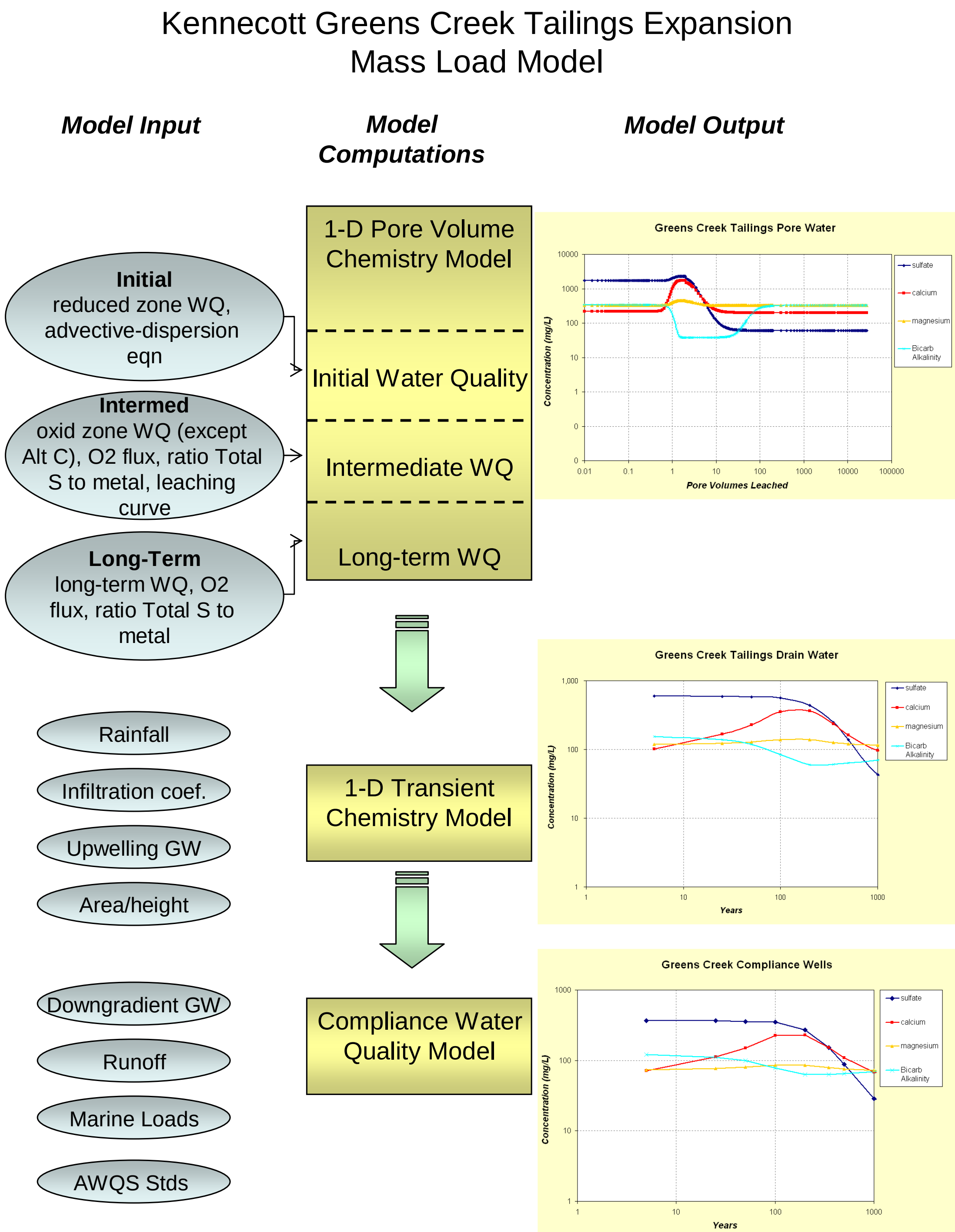

Figure 18. Schematic of Kennecott mass load model.

4.0 Model Inputs

4.1 Rainfall

The quantity of rainfall used in the model was based on data from the Juneau station that was corrected for rainfall differences between Juneau and the tailings area (section 2.2.1). The rainfall was sampled from a log-logistic distribution with a α, β, and χ values of 6.4081, 1.0112, and 0.36637, respectively. Rainfall at the tailings area was assumed to be 77% of Juneau. The average of the modeled rainfall was 1.09 m/yr (42.9 inches/year).

4.2 Infiltration

Infiltration into the tailings was equal to an infiltration coefficient times the annual rainfall. The coefficient was modeled as a variable ranging from 12 % to 15 % during operations and from 8 % to 12 % after placement of the engineered cover. The infiltration coefficient was correlated with the precipitation so that higher coefficient values were used in wetter years. The average infiltration was 0.135 m/yr (5.80 in/yr) and 0.108 m/yr (4.30 in/yr) for operating and post-closure conditions.

4.3 Flux of Tailings Seepage

The rate of water movement out of the tailings was assumed to be equal to the infiltration into the tailings, meaning the system was assumed to be at hydrologic steady-state. Consequently, the average seepage was 0.135 m/yr (5.80 in/yr) and 0.108 m/yr (4.30 in/yr) for operating and post-closure conditions.

4.4 Pore Volume Determination

Water quality is initially determined in the model as a function of pore volumes of displaced water. In order to convert from pore volumes to time, the model used:

$$1 \text{ Pore Volume } (m^3/m^2) = \text{tailings height } (m) * \text{water content } (m^3/m^3) \quad [7]$$

The residual water content was modeled as a variable ranging from 30.0 to 33.6 %, which corresponds to a suction level of 100 to 300 cm. The time required for 1 pore volume of water to be displaced through infiltration is PV (m^3/m^2) /infiltration (m/yr). Consequently, the time required to leach water through the pile is shorter on the thinner edges of the pile and longer in the middle.

4.5 Height and Area of Pile

The rate of change in water quality within the pile is affected by the pile height, which affects the translation of pore volumes into time with the mass load model. The thickness of the proposed tailings pile was estimated from AutoCAD drawings (Figure 19) at about 265 locations in a 100-foot grid. The cumulative area-thickness curve (Figure 19) was used in the model to calculate the area-weighted average concentration that exits the pile at specific times.

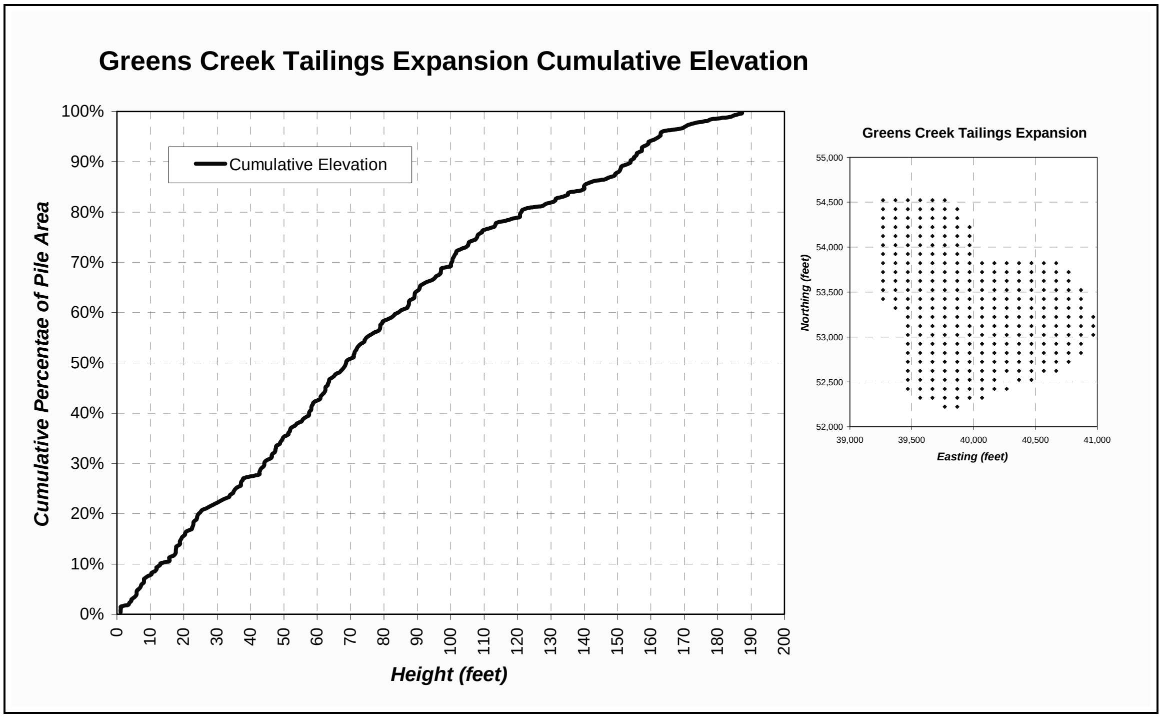

Figure 19. Cumulative area-height curve for the proposed expansion.

4.6 Upwelling Groundwater

The baseflow separation described in section 2.5.1 was used to develop a series of observed flow rates for upwelling groundwater for the period from February through October, 2001. The data fit a Pearson distribution and yielded an average upwelling groundwater rate of 28.7 gpm and a minimum of 11 and maximum of 86 gpm.

4.7 Oxygen Flux

The determination of oxygen flux was described previously in section 2.6.2. For the operational conditions, flux varied from 15 to over 300 g/m^2/yr, while post-closure the flux was around 4 g/m^2/yr (Figure 20). The model used a variable oxygen flux that approximated the range and distribution of values determined from the oxygen flux analysis at varying tailings saturation (from 70 to 85 % saturated). Oxygen penetrates about 0.4 m into the operational tailings but 0.3 m into the post-closure tailings per year.

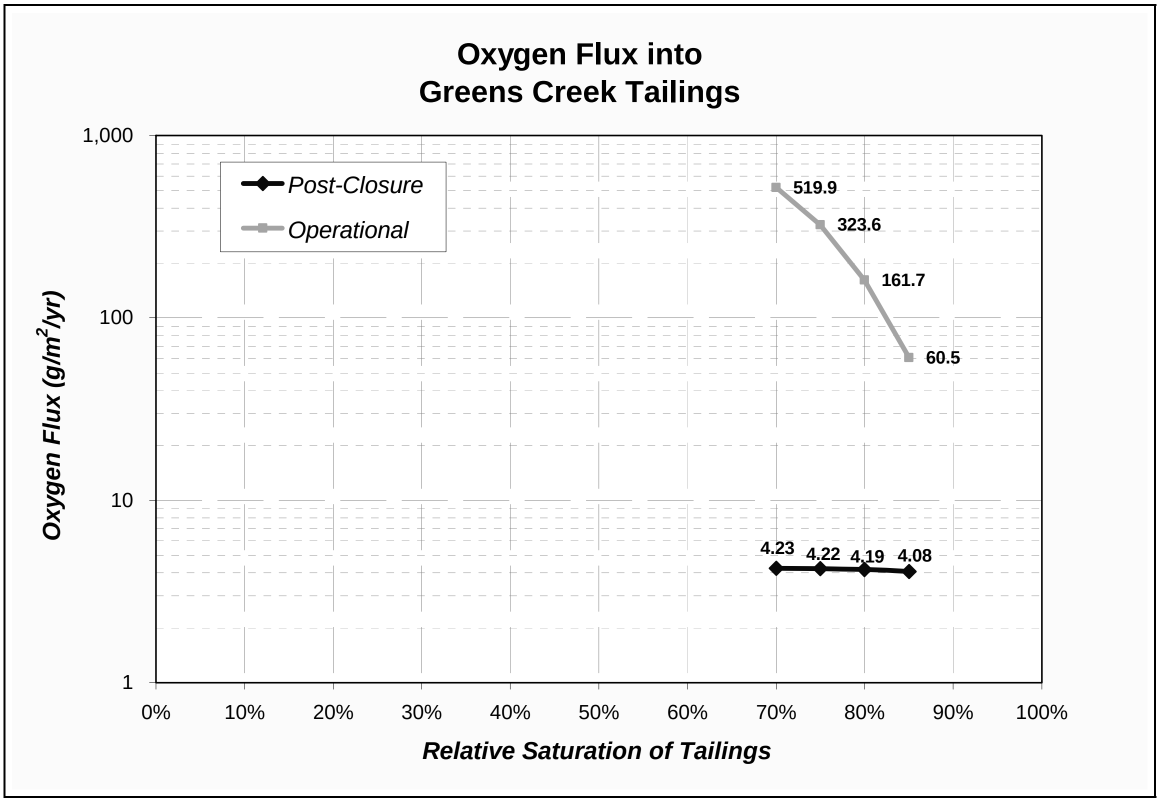

Figure 20. Predicted oxygen flux for operational and post closure conditions as a function of tailings saturation

4.8 Contact Water Chemistry

Initial Water Quality – The initial water quality after closure is the same as currently exists within the interstitial water held in the tailings pore spaces. According to the geochemical conceptual model, water held in the pore space of deeper tailings has lower concentrations of key metals than occurs in the shallow oxidized portion of the tailings. This is due to sulfate reduction, which tends to precipitate certain metals such as zinc, nickel and selenium. Initial water quality emanating from the tailings is the same for each alternative.

Intermediate Water Quality – Once the water initially held in the tailings pore space has flowed into the drain, the chemistry of the tailings water may change due to a change in the geochemical environment. For example, during operation of the tailings facility, organic carbon is added to the processing circuit. As the carbon decomposes, microbial sulfate reduction begins. After the water held in the tailings is displaced by infiltration of meteoric water, the carbon source may be removed as well. Consequently, sulfate reduction is expected to cease after one pore volume of water has flowed from the pile (except for Alternative C where carbon is added or unless persistent, or if insoluble organic compounds exist in the pile). Consequently, according to the geochemical conceptual model, the chemistry of the tailings pore water will gradually evolve toward that which is found in the shallower oxidized tailings.

The transition from initial to intermediate tailings water quality was modeled to be gradual, following the advective-dispersive equation [4].

$$C = \frac{C_0}{2}\left[\operatorname{erfc}\left(\frac{x - \bar{v}_x t}{2\sqrt{D_x t}}\right) + \exp\left(\frac{\bar{v}_x x}{D_x}\right)\operatorname{erfc}\left(\frac{x + \bar{v}_x t}{2\sqrt{D_x t}}\right)\right] \quad [4]$$

where

$\bar{v}_x$ = average linear velocity = v/n, where v = Q/A

C = liquid phase concentration

D = dispersion coefficient

ρ_b = bulk phase density

n = porosity

erfc(x) is the complimentary error function defined as 1 - erf(x) (see eqn [5]), where y is a dummy integration variable where erf (0) = 0, erf (∞) = 1, erf (-x) = - erf (x)

$$erf(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-y^2}dy \quad [5]$$

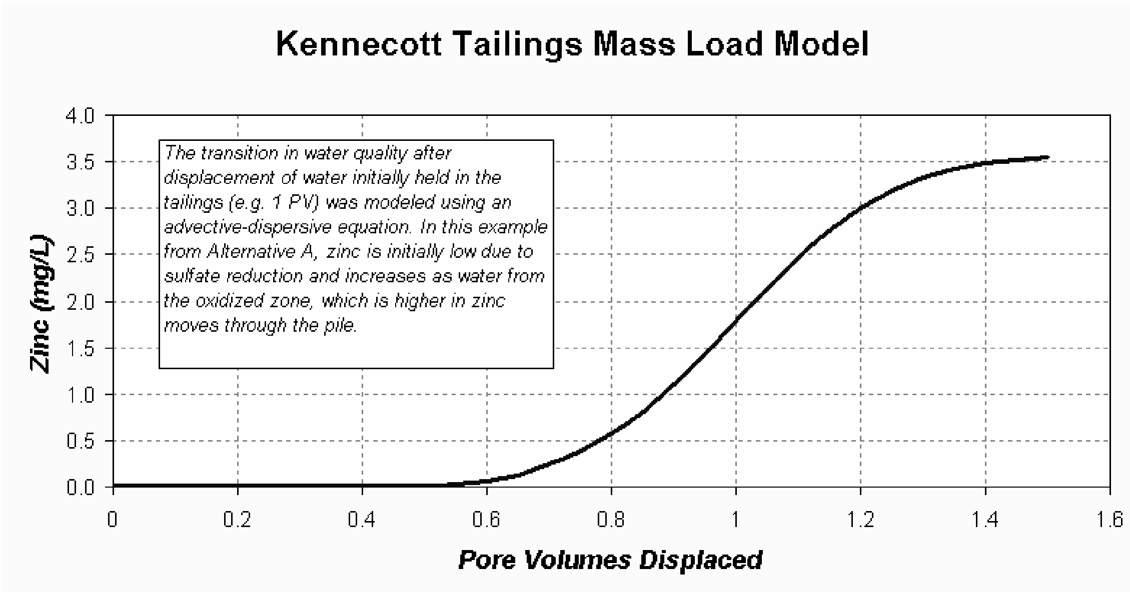

Figure 21. The transition from the initial water quality follows the advective-dispersive equation.

The chemistry during the intermediate phase is assumed to be similar to the oxidized zone of the tailings (except for Alternative C where carbon is added). Metal concentrations will remain similar to the concentrations found in the oxidized zone of the tailings as long as **oxidation by-products** that formed during the operating phase persist in the tailings.

The mass of oxidation by-products was calculated for each constituent by assuming that when the tailings are originally placed, they are in an insoluble sulfide form. As the sulfides react with oxygen, the constituents are converted to a more soluble form and they can be leached from the system or may form secondary mineral phases. The soluble variety of each constituent was assumed to accumulate at the same rate as sulfate. Therefore, the ratio of the total concentration of each constituent to total sulfur was calculated (Table 8). Next, the amount of sulfur oxidized during operations (assumed to be 20 years) was determined based on the estimated oxygen flux into the tailings (see discussion below). For each 3.75 moles of oxygen, 2 moles of sulfur are oxidized. The quantity of oxidized sulfur was multiplied times the ratio of the total constituent concentration to total sulfur to find the oxidized quantity of a constituent. The amount of the constituent leached during operations (found by multiplying the concentration in tailings seepage by the annual flux of infiltration times 20 years) was deducted from the total oxidized mass to find the remaining amount of each constituent.

Table 8. Ratio of total constituent concentration to total sulfur (Vos 1991 and Marshall 2002).

Constituent	Tailings Total Metal to Sulfide Ratio
Aluminum	23.70%
Antimony	0.26%
Arsenic	0.49%

Bicarb Alkalinity	12.86%
Boron	0.00%
Cadmium	0.10%
Calcium	65.80%
Chloride	0.10%
Chromium	0.15%
Copper	1.50%
Iron	83.22%
Lead	9.21%
Magnesium	31.70%
Manganese	2.00%
Mercury	0.01%
Nickel	0.06%
Selenium	0.01%
Silver	0.21%
Sodium	0.71%
Sulfate	100.00%
Zinc	17.79%

The oxygen flux into the tailings during operations was found in a similar manner to the oxygen flux through the engineered cover (section 2.6.2). Depending on the value used for the relative tailings saturation, oxygen flux into the operating tailings varied from 519 $g/m^2/yr$ at 70 % saturation to 60.5 $g/m^2/yr$ at 85 % saturation (Figure 20).

The duration of the intermediate chemical stage depends on the quantity of accumulated oxidation products contained in the tailings when the engineered cover is placed, and on the rate of water movement through the cover. The infiltrating water slowly dissolves the remaining oxidation products and leaches them out of the system. The model simulated the duration of the intermediate chemical phase and the transition to long-term equilibrium chemistry using an empirical model of the form in [6].

$$\frac{1}{\left(1+\alpha \times PV^{4}\right)^{\left(1+\frac{1}{4}\right)}}, \; where \; \frac{1}{\alpha} \; is \; the \; leaching \; duration \; in \; PV \; required \; to \; remove \; the \; accumulated \; mass \; of \; the \; constituent \qquad [6]$$

The unknown quantity (α) in [6] is found by dividing the mass of oxidation product described above, by the amount contained in 1 pore volume of solution (assuming oxidizing conditions). The equation yields a leaching curve that gradually transitions from the intermediate zone chemistry to the long-term equilibrium chemistry, but the model accurately reflects the total mass of accumulated oxidation products (Figure 22).

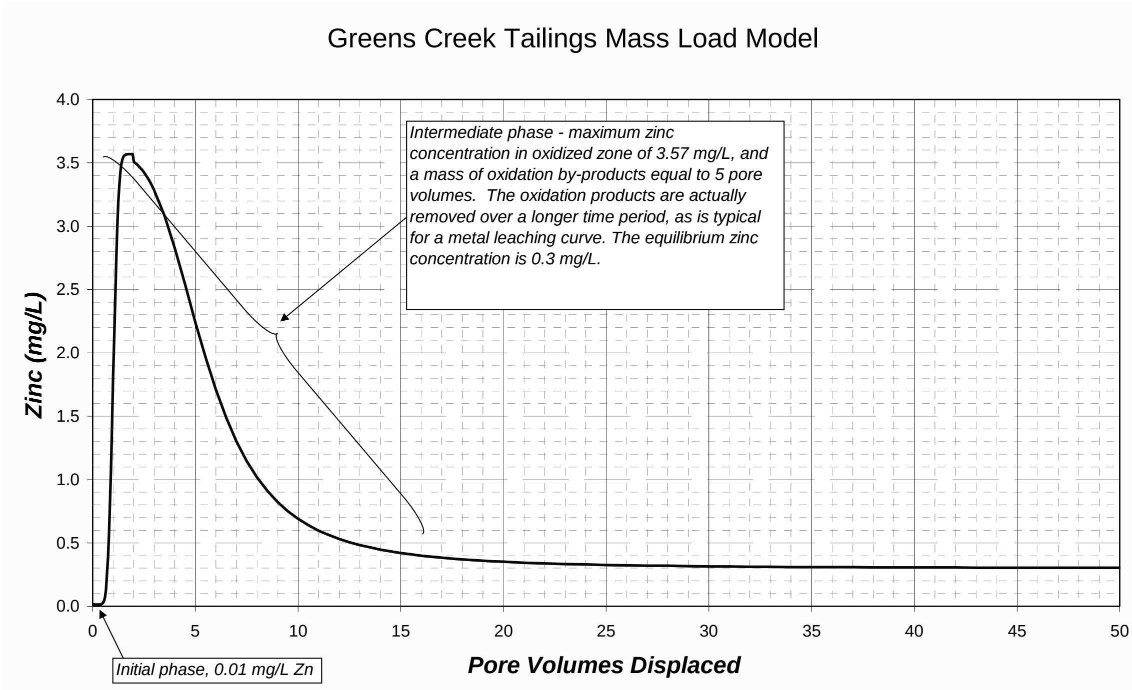

Figure 22. Predicted zinc concentrations as a function of pore volume from the mass load model.

Long-Term Water Quality – The long-term water quality represents the chemical equilibrium with the lower oxygen flux that is achieved by the engineered cover. Chemical equilibrium is not achieved until after the first pore volume of water is displaced (initial stage), and the mass of stored oxidation products are removed (intermediate stage).

The model predicts the concentration of each constituent by assuming that the rate of oxygen flux (Figure 22) controls the release of the soluble form of the constituent, and that the soluble reaction products dissolve in the available water. The long-term flux of water is described below.

4.9 Representative Water Quality

The contact water quality was estimated by fitting the existing water quality data to a statistical distribution that could be used in the @Risk model (Appendix 4). The curve-fitting model Bestfit was used for this purpose. Where most data were below the detection level, a fixed constituent concentration was used in the model. All distributions were assumed to be mutually independent in the model. Contact zone waters under oxidizing and reducing geochemical domains were estimated as follows:

- Tailings pore water (oxidized) – representative concentrations were based on lysimeter samples.
- Tailings pore water (sulfate reduction) – representative concentrations were based on samples obtained from piezometers.
- Tailings pore water (long-term) – the long-term chemistry is predicted as described in section 4.8 rather than empirically determined. Long-term sulfate is predicted based on the assumption that all oxygen flux reacts with pyrite, and that all sulfate dissolves in the infiltrating water. The metal concentration is based on the ratio of total metal to total sulfur in the tailings. For some constituents, however, the concentration is not proportional to the sulfate released by oxidation. For these elements, including calcium, magnesium, sodium, iron, manganese, bicarbonate and hardness, a minimum long-term concentration (Table 9) was fixed in the model.

The average of each statistical distribution for each constituent is listed in Table 9.

4.10 Constituents Below Detection Level

Some constituents were included in the mass load model even though they were present in less than detectable quantities in background surface and groundwater and in contact water. When a parameter was less than detection level, its concentration was input as one-half of the detection level if the most of the samples were also below detection, but at the full detection level if the parameter was detected in most other samples. Inclusion of these constituents, notably mercury and silver, can lead to confusion since the instrument detection level varied for different waters.

For example, *the mass load model employed mercury concentrations at one-half the detection level since mercury was rarely detected in receiving waters or contact waters. Because of varying detection levels, some waters modeled in the mass load model had mercury concentrations of 0.00005 mg/L and others had 0.000005 mg/L mercury. The concentration predicted by the model consists of a mixture of contact waters input at 0.00005 and groundwater or surface water input at 0.000005 mg/L. Consequently, the model results vary between the two extreme input concentrations of 0.00005 and 0.000005 mg/L.*

4.11 Flow and Chemistry in the Tailings Drains

The mass load model predicts the rate of flow and the chemical concentration for multiple constituents in tailings pore water, and in the tailings underdrain where tailings seepage mixes with upwelling groundwater. The methods used to determine the flow and chemistry of tailings seepage were described in previous sections. The rate of flow of upwelling groundwater was determined from the analysis of baseflow as described in section 4.6. The chemistry of the upwelling groundwater (Table 9) was determined from a statistical analysis of wells installed upgradient of the tailings facility (Appendix 4). The combined loads from seepage and upwelling groundwater were added to determine the characteristics of water in the drains.

Table 9. Representative water quality used in the mass load model derived from site monitoring data.

Constituent (mg/L)	Tailings Water Oxidized Zone Water	Tailings Water Sulfate Reduction Zone Water	Tailings Water Minimum Long-Term	Upwelling Ground-water	Down-gradient Ground-water	Down-gradient Surface Water
Aluminum	3.00E-01	1.93E-01		1.00E-01	1.00E-01	1.68E-01
Antimony	2.02E-02	4.07E-02		5.00E-04	5.00E-04	5.00E-05
Arsenic	1.00E-02	2.69E-02		5.00E-03	5.00E-03	2.50E-04
Barium						9.22E-03
Bicarb Alkalinity	3.81E+01	3.34E+02	3.25E+02	6.68E+01	6.68E+01	8.00E+00
Cadmium	3.76E-03	5.00E-05		5.00E-05	5.00E-05	5.00E-05
Calcium	1.72E+03	2.17E+02	2.00E+02	2.29E+01	2.29E+01	3.99E+00
Chloride	1.36E+01	2.39E+01		4.07E+00	4.07E+00	2.09E+00
Chromium	1.00E-03	7.26E-04		2.50E-04	2.50E-04	1.55E-02
Copper	3.28E-03	3.55E-03		2.50E-04	2.50E-04	4.66E-03
Hardness	1.68E+03	2.00E+03	4.00E+02	6.98E+01	6.98E+01	1.37E+01
Iron	1.92E-01	1.33E-01	5.38E+01	8.07E-01	8.07E-01	5.00E-02
Lab pH	6.04E+00	7.89E+00	7.80E+00	6.92E+00	6.92E+00	7.67E+00
Lead	2.50E-03	1.49E-03		1.00E-04	1.00E-04	1.00E-04
Magnesium	4.53E+02	3.33E+02	3.25E+02	3.63E+00	3.63E+00	9.08E-01
Manganese	1.81E+00	3.56E-01	2.16E+01	6.96E-01	6.96E-01	4.83E-03
Mercury	5.00E-05	5.00E-05		5.00E-06	5.00E-06	5.00E-06
Nickel	4.80E-02	5.98E-03		1.97E-03	1.97E-03	2.15E-03
Potassium	6.64E+01	4.50E+01		1.00E+00	1.00E+00	5.00E-01
Selenium	2.44E-01	2.90E-03		1.00E-03	1.00E-03	2.50E-04
Silver	5.00E-05	5.00E-05		5.00E-05	5.00E-05	1.90E-04
Sodium	8.95E+01	1.53E+02		4.36E+00	4.36E+00	2.17E+00
Sulfate	2.29E+03	1.72E+03		5.92E+00	5.92E+00	2.64E+00
Zinc	3.57E+00	9.37E-03		4.78E-03	4.78E-03	4.77E-03

4.12 Water Quality at Compliance Locations

Several water management options are considered by KGCMC for insuring water quality compliance. If compliance can be achieved, water from the drains may be discharged with or without dilution into shallow groundwater or surface water downgradient of the tailings facility. A water management system, which employs biological processes, may be developed to improve the quality of drain water prior to discharge. Alternatively, water may be directed in the existing pipeline to a marine discharge in Hawk Inlet, with or without a diffuser.

Finally, water can be treated prior to discharge to Hawk Inlet as currently occurs. KGCMC is likely to change their water management practices through time as the quality and quantity of contact water changes after closure.

The mass load model predicts the likely range in water quality that may occur when water from the underdrain is discharged without dilution, and when it gets diluted with surface runoff from the pile and with groundwater in the sand/peat aquifer downgradient of the tailings. Background groundwater and surface water quality were determined from statistical analysis of background water quality data and are represented in Table 9 and Appendix 4.

Water quality at the freshwater and marine water compliance points is sensitive to the chemistry of the source waters and to the relative flow rates. The variation in flow rates is shown in Figure 23, with the most erratic flows provided by surface runoff, which is zero for 54.6% of the time, and ranges up to 1,000 gpm. Under average conditions the flows from tailings seepage, upwelling groundwater, downgradient groundwater, and surface runoff are 15.3, 28.7, 27.4 and 87.4 gpm, respectively, for a total flow of 159.9 gpm.

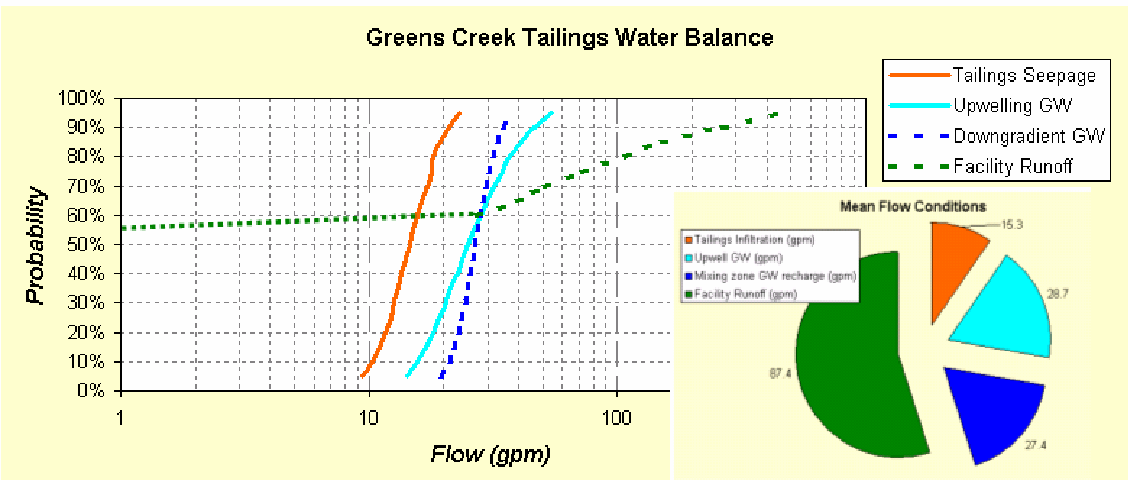

Figure 23. Cumulative probability distributions for various water flows.

4.13 Permissible Marine Discharge Load

The effluent guidelines for metals that apply to the NPDES permit are best available technology economically achievable (BAT), 40 CFR 440.103, whereas the limitations for pH and total suspended sediment (TSS) are based on best practicable control technology (BPT) 40 CFR 440.102. ADEC authorized a mixing zone for this permit having a 170:1 dilution ratio for the receiving water, even though technology-based effluent limits do not consider a mixing zone. During post-closure, the permit will be re-issued to reflect current water flows and chemistry. At that time, EPA will determine if effluent limits should be water quality based using freshwater AWQS (discharge scenario 1(a) and 1(b), or marine AWQS with a potential mixing zone (discharge scenario 2), or continue to be technology-based using BPJ (discharge scenario 3). For the purposes of comparing tailings effluent water quality to marine AWQS for discharge scenario 2, a 50:1 dilution ratio is factored into marine AWQS.

4.14 Determination of Alaska Water Quality Standards

Alaska water quality standards (AWQS) are the benchmark against which the water quality downgradient of the tailings is compared. The standards presume that the water will be suitable for all uses as described in section 2.3.4. Many of the metals criteria in the freshwater AWQS are dependent on the water's hardness. Hardness of water downgradient of the tailings facility was calculated in the model using the same techniques used for other constituents.

5.0 Model Calibration

5.1 Inputs for Operating Conditions

The purpose of the mass load model is to predict the chemistry of water in the drain and downgradient of the tailings at various times after closure of the facility. The reliability of the model can be judged, in part, by using it to predict chemistry of the current tailings facility. The best source of data to calibrate the model is from the wet wells.

5.2 Comparison to Wet Well Flow and Chemistry

The mass load model was structured to predict the flow and chemistry that occurs in the wet wells. To simulate the wet wells, waters were mixed from tailings seepage (assuming that the water is derived from the reduced zone), upwelling groundwater (using upgradient groundwater quality), and from runoff (using water quality from the oxidized tailings zone). The model was run for 1,000 iterations using a Latin Hypercube sampling technique, and the range of results were compared to observed water quality in the wet wells (Table 10).

Table 10. Water quality observed in wet wells.

Parameter Concentration	Units	Contact Underdrains			
		Wetwell 2 Main Pile 4/25/2001	Wetwell 2 Main Pile 9/7/2001	Wetwell 3 West Buttress 4/25/2001	Wetwell 3 West Buttress 9/7/2001
Acidity	*mg/l $CaCO_3$*	<10.0	<10.0	<10.0	<10.0
Aluminum	*mg/l, dissolved*	0.316	0.288	0.307	0.33
Antimony	*mg/l, dissolved*	<0.001	0.00196	<0.001	0.00498
Arsenic	*mg/l, dissolved*	0.0191	0.0212	0.00426	0.00506
Bicarb Alkalinity	*mg/l $CaCO_3$*	262	252	404	227
Cadmium	*mg/l, dissolved*	<0.0001	<0.001	0.00084	0.00743
Calcium	*mg/l, dissolved*	272	343	443	467
Chloride	*mg/l*	9.71	7.47	22.5	7.19
Chromium	*mg/l, dissolved*	<0.0005	0.00137	0.00092	0.00147
Copper	*mg/l, dissolved*	0.00104	0.00216	0.00292	0.00374
Fluoride	*mg/l*	0.21	0.272	0.184	0.233
Hardness	*mg/l*	1110	1350	2230	1710
Iron	*mg/l, dissolved*	15.5	19.3	15.8	2.35
Lab pH	*s.u.*	6.77	6.5	6.62	6.43
Lab Spec. Cond.	μS/cm	1790	2050	3350	2570
Lead	*mg/l, dissolved*	<0.0002	0.00143	<0.0002	0.005
Magnesium	*mg/l, dissolved*	105	121	273	132

Parameter Concentration	Units	Contact Underdrains			
		Wetwell 2 Main Pile 4/25/2001	Wetwell 2 Main Pile 9/7/2001	Wetwell 3 West Buttress 4/25/2001	Wetwell 3 West Buttress 9/7/2001
Manganese	*mg/l, dissolved*	3.24	4.82	9.66	4.17
Mercury	*mg/l, dissolved*	<0.00001	<0.00001	<0.00001	<0.00001
Nickel	*mg/l, dissolved*	0.054	0.122	0.0591	0.2
Potassium	*mg/l, dissolved*	9.47	10.5	18.9	10.2
Selenium	*mg/l, dissolved*	0.00188	0.00244	0.00335	0.00747
Silica	*mg/l*	10.4	9.78	17.8	7.22
Silver	*mg/l, dissolved*	<0.0001	<0.001	<0.0001	<0.001
Sodium	*mg/l, dissolved*	25.1	23	49.6	21.9
Sulfate	*mg/l*	840	1130	2070	1580
Sulfide	*mg/l*	<0.05		<0.05	
TDS	*mg/l*	1500	1900	3200	2600
Total Alkalinity	*mg/l $CaCO_3$*	262	252	404	227
TSS	*mg/l*	25	22	34	<4.0
Zinc	*mg/l, dissolved*	1.2	2.11	1.45	3.71

The constituent concentrations in the wet wells predicted by the mass load model are presented in Figure 24 to 28 for the lowest probable (10 % probability), the highest probable (90 % probability), and median (50 % probability). The 10^{th} to 90^{th} percentile is shown as a shaded region while the median is a line. Additionally, the minimum and maximum actual wet well concentrations are plotted as single points for each constituent.

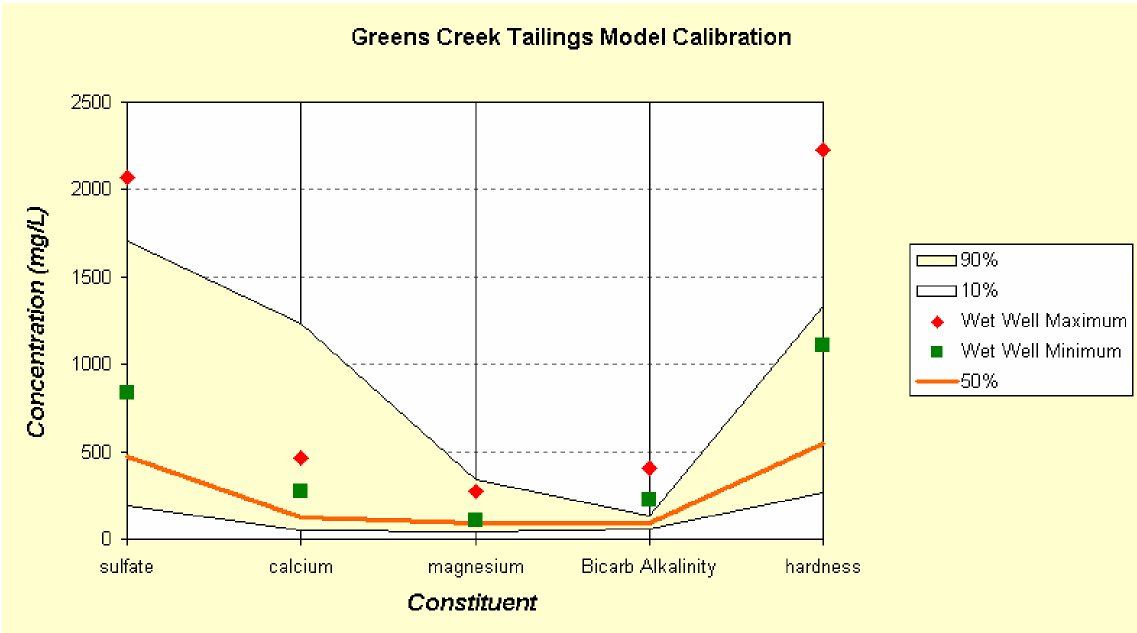

Figure 24. Predicted and actual concentrations of common ions in the wet wells.

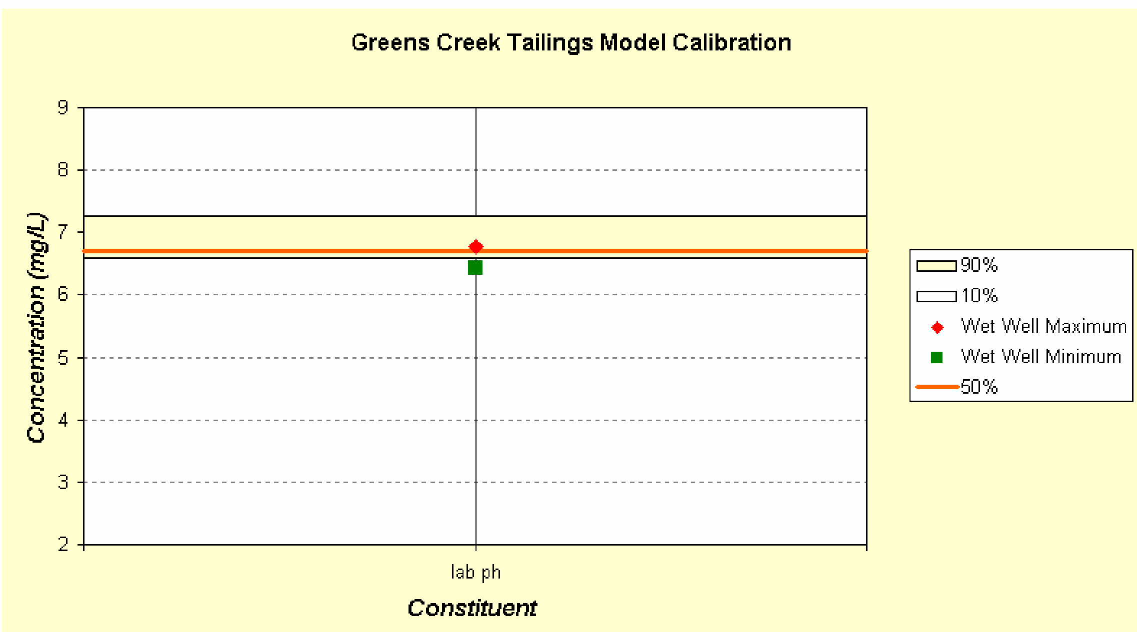

Figure 25. Predicted and actual pH in the wet wells.

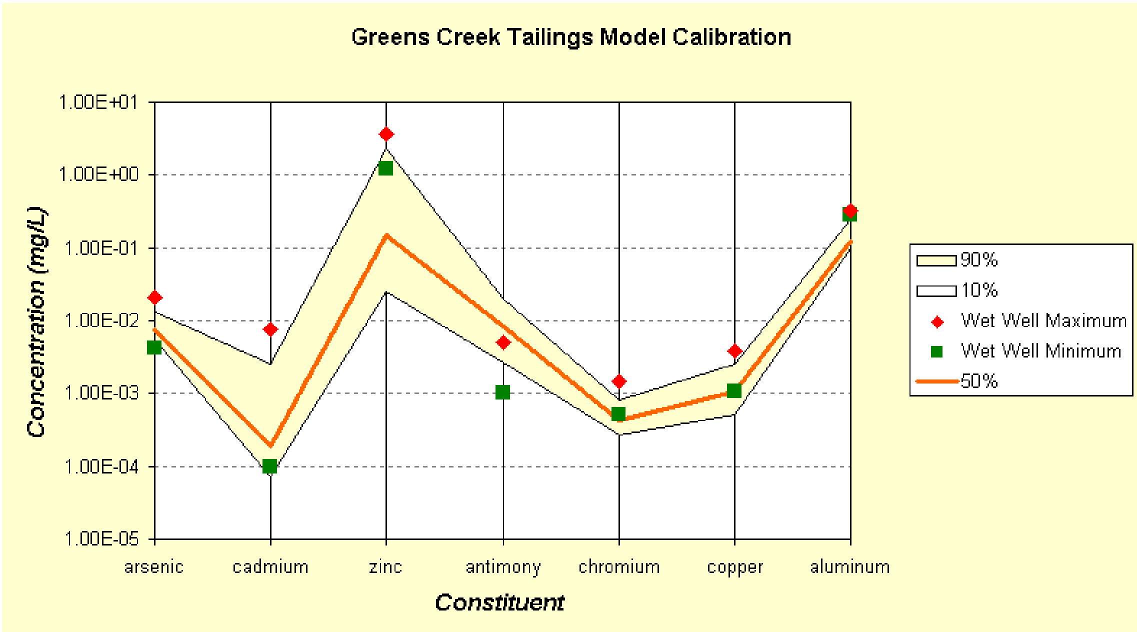

Figure 26. Predicted and actual concentrations of trace elements arsenic, cadmium, zinc, antimony, chromium, copper, and aluminum in the wet wells.

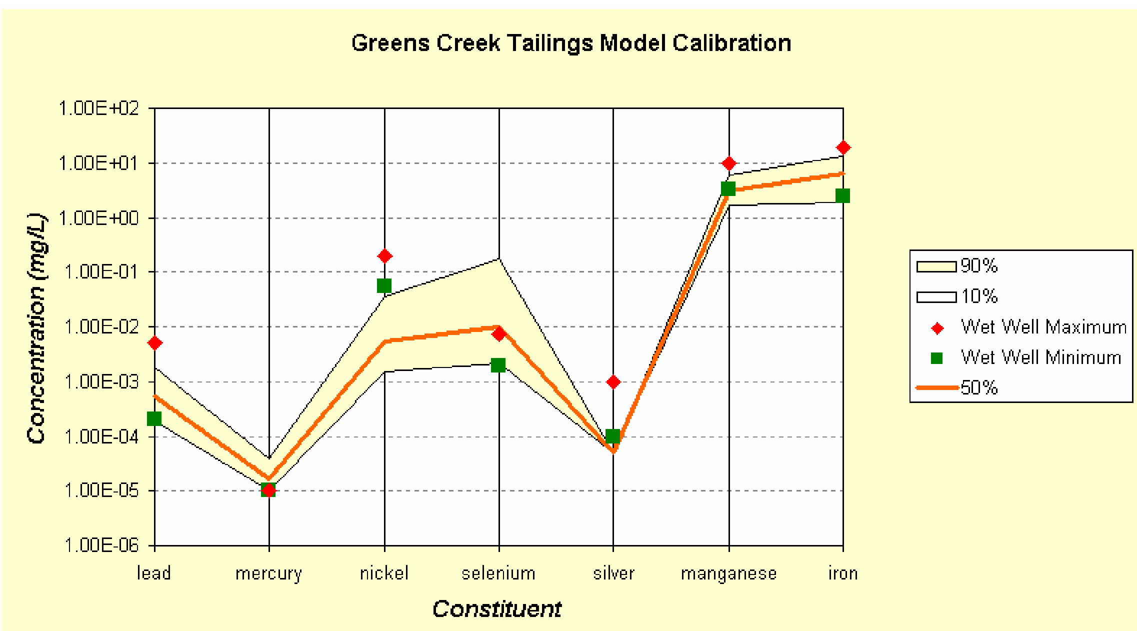

Figure 27. Predicted and actual concentrations of trace elements lead, mercury, nickel, selenium, silver, manganese, and iron in the wet wells.

The model provided relatively close agreement with observed wet well chemistry with a few exceptions. Among common ions (Figure 24) wet wells had higher sulfate, bicarbonate and hardness than predicted. The higher sulfate is attributed to interaction of upwelling groundwater with the mineralized rock used to construct the drains. Oxidation of the drain material releases sulfate, and probably also accounts for the higher than predicted zinc and nickel observed in wet wells (Figure 26) (See Section 2.6.4 for a discussion of this phenomenon.). Overall, the mass load model provided good agreement with the measured wet well chemistry.

6.0 Model Simulations

The mass load model was used to predict water quality 5, 25, 50, 100, 200, 350, 500, 1000, and 2500 years after placement of the engineered cover. The model results are stochastic meaning that the potential variability of input parameters was considered in the range of model results. To complete the probabilistic analysis, 1,000 iterations of the model were completed and the model results are expressed as a range and distribution of values. Throughout this section, the “most probable” value refers to the median (or 50th percentile) of the statistical distribution of model results. In the graphical results, the range of predicted sulfate, zinc and pH are shown. The region shaded in gray represents the 5th to 95th percentile values, while the yellow shaded areas represent a range of 1 standard deviation above and below the mean (roughly the 15th to 85th percentile).

6.1 Modeled Alternatives

Each of the alternatives from the EIS was simulated using the mass load model. The data and assumptions used for each simulation are described in Table 11.

Table 11. Summary table of results.

Alternative	Alternative A	Alternative B	Alternative C	Alternative D
Description	**No action - complete tailings placement within currently permitted facility**	**Proposed Action - place additional 6 million tons of tailings in expanded facility**	**East Ridge and Monument Value option - adjust permit boundaries compared to Alternative B and evaluate use of carbon amendments as a continuous addition or as a veneer**	**Add carbonate (limestone) to entire volume of new tailings. The tailings footprint would expand to 81 acres**
Tailings Placement Area	23.2 existing, up to 29 acres	61.3 acres	62.2 acres	81.5 acres
Chemistry of Tailings Pore Water				
Initial tailings pore water (0 to 1 pore volume)	Water from the lower portion of the pile represented by the samples from the piezometers and in which sulfate reduction is occurring. Concentrations of iron, manganese, zinc, selenium, and nickel are higher in wet wells during base flow than are found in saturated zone water. Consequently, these elements may be added by some other process and are expected to remain elevated during initial rinsing of the pile.			
Intermediate tailings pore water (1 to tens of pore volumes)	Water from the upper oxidized portion of the pile will replace the reduced water as carbon supplies are exhausted. Water chemistry is best represented by the shallow lysimeters.	Water from the upper oxidized portion of the pile will replace the reduced water as carbon supplies are exhausted. Water chemistry is best represented by the shallow lysimeters.	Water will become completely reduced as the added carbon initiates sulfate reduction. Water chemistry is best represented by the piezometers samples in which sulfate reduction has occurred.	Water from the upper oxidized portion of the pile will replace the reduced water as carbon supplies are exhausted. Water chemistry is best represented by the shallow lysimeters.
Long-term tailings pore water (>tens of pore volumes)	Water will retain the higher sulfate and trace element concentrations associated with the oxidized zone waters until the accumulated secondary minerals are rinsed from the tailings. Thereafter, concentrations will decline to lower equilibrium concentrations determined by the rate of long-term oxygen flux into the pile. Concentrations of calcium, magnesium, and bicarbonate will remain stable due to dissolution from carbonates in the tailings.	Water will retain the higher sulfate and trace element concentrations associated with the oxidized zone waters until the accumulated secondary minerals are rinsed from the tailings. Thereafter, concentrations will decline to lower equilibrium concentrations determined by the rate of long-term oxygen flux into the pile. Concentrations of calcium, magnesium, and bicarbonate will remain stable due to dissolution from carbonates in the tailings.	Water will remain reducing so that concentrations will change little. Some elements may decrease in concentration in response to decreased oxygen flux.	Water will retain the higher sulfate and trace element concentrations associated with the oxidized zone waters until the accumulated secondary minerals are rinsed from the tailings. Thereafter, concentrations will decline to lower equilibrium concentrations determined by the rate of long-term oxygen flux into the pile. Concentrations of calcium, magnesium, and bicarbonate will remain stable due to dissolution from carbonates in the tailings.

Table 11 Continued - Summary table of results.

Alternative	Alternative A	Alternative B	Alternative C	Alternative D
Description	**No action - complete tailings placement within currently permitted facility**	**Proposed Action - place additional 6 million tons of tailings in expanded facility**	**East Ridge and Monument Value option - adjust permit boundaries compared to Alternative B and evaluate use of carbon amendments as a continuous addition or as a veneer**	**Add carbonate (limestone) to entire volume of new tailings. The tailings footprint would expand to 81 acres**
Average Annual Rainfall (m)	Rainfall at Juneau was fit to a distribution described by "RiskLoglogistic(0.36637, 1.0112, 6.4081)". The amount was decreased to 77 % of Juneau precipitation based on comparison with rainfall at the mine for 1997 to 2001.			
Infiltration coefficient (operational)	=RiskTriang(0.1,0.12,0.15)			
Infiltration coefficient (post-closure)	=RiskTriang(0.08,0.1,0.12)			
Residual Water Content (vol/vol)	=RiskTriang(0.3,0.31,0.336)			
Oxygen flux (operational) (M/m2/y)	=RiskExtvalue(5.3396, 3.7735, RiskTruncate(0.436, 10.07),RiskName("Op O2 Flux"), RiskDepC("WaterContent",-0.85))			
Oxygen flux (closure) (M/m2/y)	=RiskTriang(0.127,0.13,0.131)			
Operating Period (y)	20			
Oxygenated depth (m)	1			
Dispersion coefficient	0.02			
Upwelling Groundwater (gpm)	=RiskPearson5(4.716,103.75,RiskShift(1.1175),RiskTruncate(11.5,1.5*57.2))			
Dilution Zone Assumptions				
Area (m2)	=500 m *1000 m			
Recharge Rate	0.1			
Groundwater Recharge (m3/day)	Area + Recharge Rate * Rain			
Runoff (gpm)	=(69/18.3)*RiskPearson5(0.7197, 7.3715, RiskShift(3.5269))*RiskDiscrete({0,1}, {0.546,0.454})			

Note: "Risk…:" are formulas from @Risk software

6.2 Mass Load Model Results

Surface water and groundwater quality downgradient of the tailings in the Hawk Inlet drainages may be affected by one or more of the four project alternatives. Activities that could affect surface water and groundwater quality include tailings placement and surface reclamation. These activities will result in geochemical and biological processes occurring within the tailings pore water, and geochemical and physical processes that occur on the surface of the pile, which could increase metal and sulfate ion concentrations.

The mass load model was developed to simulate the complex geochemical and biological processes within the tailings, and the hydrologic connections between groundwater and surface water downgradient of the tailings.

A summary of the mass load model results is described below for each alternative. Median results are shown for common ions and certain metals, including those that are currently monitored as part of the mine's water quality monitoring program or are monitored as a requirement of the mine's NPDES permit. Results are given for several distinct time periods, beginning shortly after closure is completed, and continuing over hundreds of years.

The predicted median water quality in the underdrain and at a downgradient compliance point were compared to relevant AWQS to determine whether standards are likely to be met. For certain metals, the freshwater AWQS is hardness dependent. The hardness of water in the underdrain, or after mixture of underdrain water with downgradient surface and groundwater was predicted using the mass load model. Therefore, a separate value of hardness was used for determining the freshwater AWQS for every time period modeled. Consequently, the freshwater AWQS is slightly different for each row of the tables presenting the model results (Tables 12 to 20). To simplify the comparison to AWQS, a value is colored red if it exceeds AWQS. The AWQS value presented in the tables is the range of standards calculated during the time period based on the hardness for a given year in the underdrain or receiving water.

Water quality predictions for flow from the underdrain (discharge scenario 1(a)) and water flowing out of the underdrain diluted with receiving surface water and groundwater (discharge scenario 1(b) are shown. For discharge scenario 1(b), underdrain water is assumed to become instantaneously diluted with surface runoff from the pile and downgradient groundwater, and that dilution will be complete by the time the waters reach a compliance location prescribed by the regulatory agencies. This could be accomplished using a treatment works that could also utilize various chemical and physical processes such as oxidation, adsorption, dilution and dispersion that may occur in surface water or groundwater downgradient of the tailings facility. Water quality predictions are also made for flow from the underdrain that is discharged to marine waters (discharge scenario 2), using an assumed dilution ratio of 50:1. This assumption is reasonable, given the existing 170:1 dilution ratio approved by ADEC in the existing NPDES permit.

The results of the water quality modeling do not reflect a change in water chemistry resulting from existing water treatment processes. As described in Chapter 2 of the SEIS, KGCMC will continue an appropriate method of water treatment until such time that the tailings effluent can be discharged without treatment in such a manner so that applicable AWQS are met.

6.2.1 Alternative A No Action

Results from the mass load water quality model for Alternative A are shown in Tables 12 and 13, and Figure 28. Results indicate that exceedances to fresh water AWQS (discharge scenario 1(a) without dilution) for sulfate and antimony are initially predicted for underdrain water. After 25 years, antimony levels should have dropped below AWQS, but selenium may increase and could exceed AWQS. After 200 years, sulfate should decline below AWQS; however, zinc concentrations are predicted to have risen above AWQS. After 500 years, cadmium levels may be above AWQS. Without treatment, none of these substances exceeds AWQS initially at the compliance point where underdrain flow mixes with surface water and groundwater (discharge scenario 1(b) with dilution), but selenium, zinc and cadmium levels are predicted to have exceeded AWQS after 100, 350, and 1000 years, respectively. Selenium levels are predicted to have fallen back below AWQS after 350 years. These predicted exceedances of AWQS under discharge scenario 1 may impair existing protected water use classes if discharged without treatment. KGCMC will continue an appropriate method of water treatment until the tailings effluent can be discharged without treatment so that applicable AWQS are met.

Model results compared to AWQS for marine water (discharge scenario 2) using a 50:1 dilution show there are no exceedences.

The predicted load of metals was compared to the currently allowable loads under the existing discharge permit using a diffuser in Hawk Inlet. Predicted loads were less than one percent of allowable loads for Alternative A for all metals in the permit.

Effects to water quality in the Hawk Inlet drainage would be considered significant if tailings effluent is discharged (without treatment) to surface water or groundwater without dilution (discharge scenario 1(a), or diluted (without treatment) with surface water or groundwater prior to discharge to these receiving waters (discharge scenario 1(b)). There would be negligible adverse effects if tailings effluent is discharged without treatment directly to Hawk Inlet (discharge scenario 2). There would be negligible adverse effects if tailings effluent is discharged without treatment through the diffuser into Hawk Inlet (discharge scenario 3). If water treatment were continued in perpetuity, there would be negligible adverse effects to receiving surface water, groundwater or marine water.

NOTE: For all alternatives and tables - the hardness downgradient of the tailings facility was calculated in the mass load model. Consequently, the predicted hardness used to calculate allowable metal concentrations was the predicted hardness in the combined drain water and receiving water.

Table 12. Alternative A – Predicted concentration of common ions in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative A – Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS	250			6 to 9	0.050	0.0003 to 0.0006	0.164 to 0.382
5	**286**	61	7.0	110	0.007	0.0001	0.020
25	**285**	90	6.9	103	0.007	0.0001	0.093
50	**282**	119	6.8	92	0.007	0.0002	0.171
100	**266**	172	6.8	76	0.006	0.0004	0.317
200	205	177	6.8	65	0.006	0.0005	**0.428**
350	118	122	6.9	64	0.005	0.0005	**0.443**
500	70	91	6.9	66	0.005	**0.0005**	**0.439**
1000	25	61	7.0	70	0.005	**0.0005**	**0.428**
2500	16	53	7.0	80	0.005	**0.0005**	**0.419**
Tailings Seepage (gpm)	**5.3**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**34.0**						

Alternative A - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
Background	6	22	7.0	66	0.005	0.00004	0.0025
AWQS	250			6 to 9	0.050	0.0002 to 0.0004	0.106 to 0.241
5	129	36	7.0	76	0.006	0.0001	0.011
25	129	50	6.9	72	0.006	0.0001	0.044
50	126	64	6.9	68	0.005	0.0001	0.080
100	121	87	6.8	60	0.005	0.0002	0.144
200	94	90	6.8	55	0.005	0.0002	0.189
350	54	65	6.9	55	0.005	0.0002	**0.196**
500	34	50	6.9	55	0.005	0.0002	**0.194**
1000	13	36	7.0	57	0.005	**0.0002**	**0.186**
2500	9	33	7.0	62	0.005	**0.0002**	**0.184**
Downgradient GW (gpm)	**27.5**						
Downgradient SW (gpm)	**26.6**						
Total Flow (gpm)	**88.1**						

Alternative A - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS	NA	NA	6 to 9	NA	1.8	0.4	4.1
5	286	61	7.0	110	0.007	0.0001	0.020
25	285	90	6.9	103	0.007	0.0001	0.093
50	282	119	6.8	92	0.007	0.0002	0.171
100	266	172	6.8	76	0.006	0.0004	0.317
200	205	177	6.8	65	0.006	0.0005	0.428
350	118	122	6.9	64	0.005	0.0005	0.443
500	70	91	6.9	66	0.005	0.0005	0.439
1000	25	61	7.0	70	0.005	0.0005	0.428
2500	16	53	7.0	80	0.005	0.0005	0.419
Tailings Seepage (gpm)	**5.3**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**34.0**						

Table 13. Alternative A – Predicted concentration of trace elements in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative A - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
AWQS	0.006	0.102 to 0.231	0.0125 to 0.0293	0.0038 to 0.0109	0.00077	0.072 to 0.168	0.005	0.007 to 0.037
5	**0.006**	0.0003	0.0007	0.0003	<0.000008	0.003	0.002	<0.00005
25	0.006	0.0003	0.0007	0.0003	<0.000008	0.003	**0.006**	<0.00005
50	0.005	0.0003	0.0007	0.0004	<0.000008	0.004	**0.009**	<0.00005
100	0.004	0.0004	0.0007	0.0004	<0.000008	0.006	**0.016**	<0.00005
200	0.003	0.0004	0.0007	0.0004	<0.000008	0.006	**0.016**	<0.00005
350	0.003	0.0004	0.0007	0.0004	<0.000008	0.005	**0.010**	<0.00005
500	0.003	0.0004	0.0007	0.0004	<0.000008	0.005	**0.006**	<0.00005
1000	0.003	0.0004	0.0007	0.0004	<0.000008	0.004	0.002	<0.00005
2500	0.003	0.0004	0.0007	0.0004	<0.000008	0.003	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Tailings Seepage (gpm)	***5.3***
Upwelling GW (gpm)	***28.7***
Total Flow (gpm)	***34***

Alternative A - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
Background	0.0004	0.0002	0.0002	0.0001	0.000004	0.002	0.001	0.00004
AWQS	0.006	0.067 to 0.148	0.0080 to 0.0184	0.0020 to 0.0055	0.00077	0.047 to 0.106	0.005	0.0028 to 0.0147
5	0.003	0.0003	0.0004	0.0002	<0.000008	0.002	0.001	<0.00005
25	0.003	0.0003	0.0004	0.0002	<0.000008	0.002	0.003	<0.00005
50	0.002	0.0003	0.0004	0.0002	<0.000008	0.002	0.005	<0.00005
100	0.002	0.0003	0.0004	0.0002	<0.000008	0.003	**0.007**	<0.00005
200	0.002	0.0003	0.0004	0.0002	<0.000008	0.003	**0.007**	<0.00005
350	0.001	0.0003	0.0004	0.0002	<0.000008	0.003	0.004	<0.00005
500	0.001	0.0003	0.0004	0.0002	<0.000008	0.003	0.003	<0.00005
1000	0.001	0.0003	0.0004	0.0002	<0.000008	0.002	0.001	<0.00005
2500	0.001	0.0003	0.0004	0.0002	<0.000008	0.002	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Downgradient GW (gpm)	**27.5**
Downgradient SW (gpm)	**26.6**
Total Flow (gpm)	**88.1**

Alternative A - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
AWQS	NA	NA	0.155	0.405	0.0470	0.410	3.550	0.095
5	0.0061	0.0003	0.0007	0.0003	<0.000008	0.003	0.002	<0.00005
25	0.0057	0.0003	0.0007	0.0003	<0.000008	0.003	0.006	<0.00005
50	0.0051	0.0003	0.0007	0.0004	<0.000008	0.004	0.009	<0.00005
100	0.0041	0.0004	0.0007	0.0004	<0.000008	0.006	0.016	<0.00005
200	0.0032	0.0004	0.0007	0.0004	<0.000008	0.006	0.016	<0.00005
350	0.0030	0.0004	0.0007	0.0004	<0.000008	0.005	0.010	<0.00005
500	0.0030	0.0004	0.0007	0.0004	<0.000008	0.005	0.006	<0.00005
1000	0.0030	0.0004	0.0007	0.0004	<0.000008	0.004	0.002	<0.00005
2500	0.0030	0.0004	0.0007	0.0004	<0.000008	0.003	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Tailings Seepage (gpm)	***5.3***
Upwelling GW (gpm)	***28.7***
Total Flow (gpm)	***34***

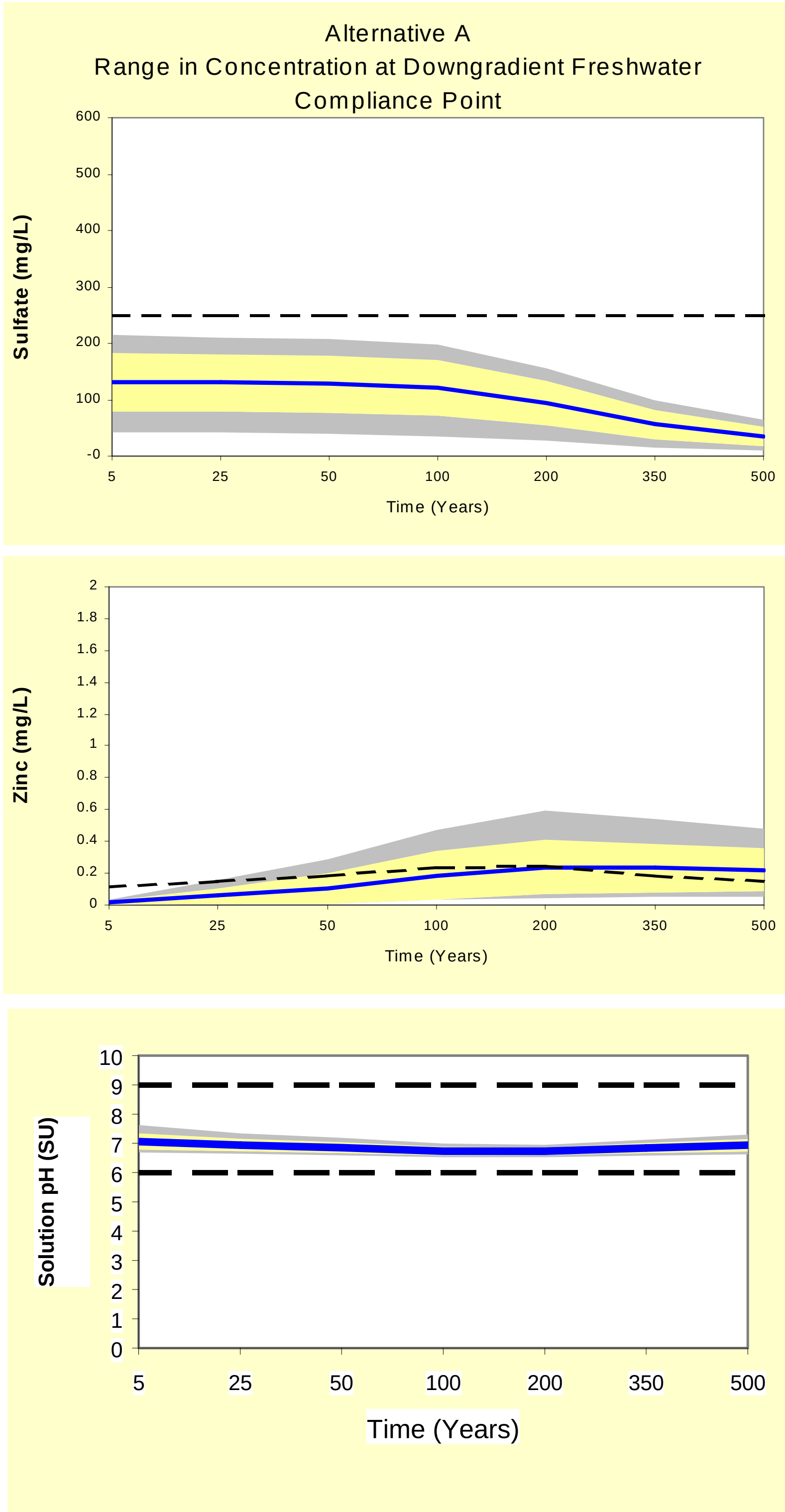

Figure 28. Alternative A - Range in concentration at compliance point.

6.2.2 Alternative B - Proposed Action

Results from the mass load model for Alternative B are shown in Tables 14 and 15, and Figure 29. Results from the water quality model for Alternative B are shown in Figure 4-5 and Table 4-3. Results are similar to those for Alternative A, indicating that sulfate and antimony would initially exceed fresh water AWQS in the underdrain flow without dilution, (discharge scenario 1(a)). After 25 years, increased selenium levels are predicted to have exceeded AWQS in the underdrain. After 100 years, cadmium and zinc levels are predicted to have exceeded AWQS. Antimony and sulfate concentrations are expected to have dropped below AWQS after 200 years, followed by selenium after 500 years. Without treatment, only sulfate would initially exceed fresh water AWQS with dilution under discharge scenario 1(b), but selenium, zinc and cadmium are expected to be in exceedence of fresh water AWQS at 25, 200 and 500 years, respectively. KGCMC will continue an appropriate method of water treatment until the tailings effluent can be discharged without treatment so that applicable AWQS are met.

Model results for Alternative B compared to AWQS for marine water using a 50:1 dilution are the same as for Alternative A. The predicted load of metals was compared to the currently allowable loads under the NPDES discharge permit using a diffuser in Hawk Inlet. Predicted loads were less than 1 percent of allowable loads for Alternative B for all metals in the permit.

Effects to water quality in the Hawk Inlet drainage and in Hawk Inlet would be the same as those identified under Alternative A.

Table 14. Alternative B – Predicted concentration of common ions in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative B - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS	250			6 to 9	0.050	0.0005 to 0.0006	0.258 to 0.382
5	**616**	102	7.1	160	0.011	0.0001	0.040
25	**619**	165	6.9	142	0.010	0.0003	0.200
50	**606**	229	6.8	121	0.009	0.0005	0.376
100	**568**	347	6.6	86	0.008	**0.0008**	**0.699**
200	**429**	355	6.6	63	0.006	**0.0011**	**0.940**
350	243	239	6.8	63	0.006	**0.0011**	**0.959**
500	144	170	6.9	65	0.006	**0.0011**	**0.954**
1000	46	105	7.1	73	0.006	**0.0011**	**0.918**
2500	28	89	7.1	92	0.006	**0.0011**	**0.907**
Tailings Seepage (gpm)	**15.3**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**44.0**						

Alternative B - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
Background	6	22	7.1	66	0.005	0.00004	0.0027
AWQS	250		6 to 9		0.050	0.0003 to 0.0006	0.158 to 0.382
5	**285**	56	7.0	97	0.007	0.0001	0.018
25	**288**	88	6.9	88	0.006	0.0001	0.085
50	**283**	116	6.8	77	0.006	0.0002	0.160
100	**262**	167	6.7	59	0.006	0.0004	0.293
200	197	170	6.7	49	0.005	0.0005	**0.388**
350	109	117	6.8	49	0.005	0.0005	**0.406**
500	63	86	6.9	50	0.005	**0.0005**	**0.401**
1000	22	57	7.0	54	0.005	**0.0005**	**0.394**
2500	15	51	7.0	65	0.005	**0.0005**	**0.386**
Downgradient GW (gpm)	**27.5**						
Downgradient SW (gpm)	**74.6**						
Total Flow (gpm)	**146.1**						

Alternative B - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS (yr 50)	NA	NA	6 to 9	NA	1.8	0.4	4.1
5	616	102	7.1	160	0.011	0.0001	0.040
25	619	165	6.9	142	0.010	0.0003	0.200
50	606	229	6.8	121	0.009	0.0005	0.376
100	568	347	6.6	86	0.008	0.0008	0.699
200	429	355	6.6	63	0.006	0.0011	0.940
350	243	239	6.8	63	0.006	0.0011	0.959
500	144	170	6.9	65	0.006	0.0011	0.954
1000	46	105	7.1	73	0.006	0.0011	0.918
2500	28	89	7.1	92	0.006	0.0011	0.907
Tailings Seepage (gpm)	**15.3**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**44.0**						

Table 15. Alternative B - Predicted concentration of trace elements in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative B - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
AWQS	0.006	0.158 to 0.231	0.0197 to 0.0293	0.0067 to 0.0109	0.00077	0.113 to 0.168	0.005	0.017 to 0.037
5	**0.0124**	0.0004	0.0013	0.0005	<0.00002	0.003	0.003	<0.00005
25	**0.0116**	0.0004	0.0014	0.0006	<0.00002	0.005	**0.011**	<0.00005
50	**0.0107**	0.0005	0.0013	0.0007	<0.00002	0.007	**0.019**	<0.00005
100	**0.0084**	0.0005	0.0013	0.0007	<0.00002	0.010	**0.033**	<0.00005
200	**0.0061**	0.0005	0.0012	0.0007	<0.00002	0.011	**0.034**	<0.00005
350	0.0058	0.0005	0.0012	0.0007	<0.00002	0.009	**0.020**	<0.00005
500	0.0058	0.0005	0.0012	0.0007	<0.00002	0.008	**0.011**	<0.00005
1000	0.0058	0.0005	0.0012	0.0007	<0.00002	0.006	0.003	<0.00005
2500	0.0058	0.0005	0.0012	0.0007	<0.00002	0.006	0.002	<0.00005

Data for mercury and silver are below detection in representative contact waters
Tailings Seepage (gpm) ***15.3***
Upwelling GW (gpm) ***28.7***
Total Flow (gpm) ***44***

Alternative B - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
Background	0.0004	0.0002	0.0002	0.0001	0.000004	0.001	0.001	0.00004
AWQS	0.006	0.098 to 0.231	0.0120 to 0.0293	0.0032 to 0.0109	0.00077	0.069 to 0.168	0.005	0.0062 to 0.0374
5	0.005	0.0003	0.0007	0.0003	<0.00001	0.002	0.002	<0.00005
25	0.005	0.0003	0.0007	0.0003	<0.00001	0.003	**0.005**	<0.00005
50	0.005	0.0003	0.0007	0.0003	<0.00001	0.004	**0.009**	<0.00005
100	0.004	0.0003	0.0007	0.0004	<0.00001	0.005	**0.014**	<0.00005
200	0.003	0.0004	0.0006	0.0004	<0.00001	0.006	**0.015**	<0.00005
350	0.003	0.0004	0.0006	0.0004	<0.00001	0.005	**0.009**	<0.00005
500	0.003	0.0004	0.0006	0.0004	<0.00001	0.004	**0.005**	<0.00005
1000	0.003	0.0004	0.0006	0.0004	<0.00001	0.003	0.002	<0.00005
2500	0.003	0.0004	0.0006	0.0004	<0.00001	0.003	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters
Downgradient GW (gpm) **27.5**
Downgradient SW (gpm) **74.6**
Total Flow (gpm) **146.1**

Alternative B - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver
AWQS	NA	NA	0.155	0.405	0.0470	0.410	3.550	0.095
5	0.0124	0.0004	0.0013	0.0005	<0.00002	0.003	0.003	<0.00005
25	0.0116	0.0004	0.0014	0.0006	<0.00002	0.005	0.011	<0.00005
50	0.0107	0.0005	0.0013	0.0007	<0.00002	0.007	0.019	<0.00005
100	0.0084	0.0005	0.0013	0.0007	<0.00002	0.010	0.033	<0.00005
200	0.0061	0.0005	0.0012	0.0007	<0.00002	0.011	0.034	<0.00005
350	0.0058	0.0005	0.0012	0.0007	<0.00002	0.009	0.020	<0.00005
500	0.0058	0.0005	0.0012	0.0007	<0.00002	0.008	0.011	<0.00005
1000	0.0058	0.0005	0.0012	0.0007	<0.00002	0.006	0.003	<0.00005
2500	0.0058	0.0005	0.0012	0.0007	<0.00002	0.006	0.002	<0.00005

Data for mercury and silver are below detection in representative contact waters
Tailings Seepage (gpm) ***15.3***
Upwelling GW (gpm) ***28.7***
Total Flow (gpm) ***44***

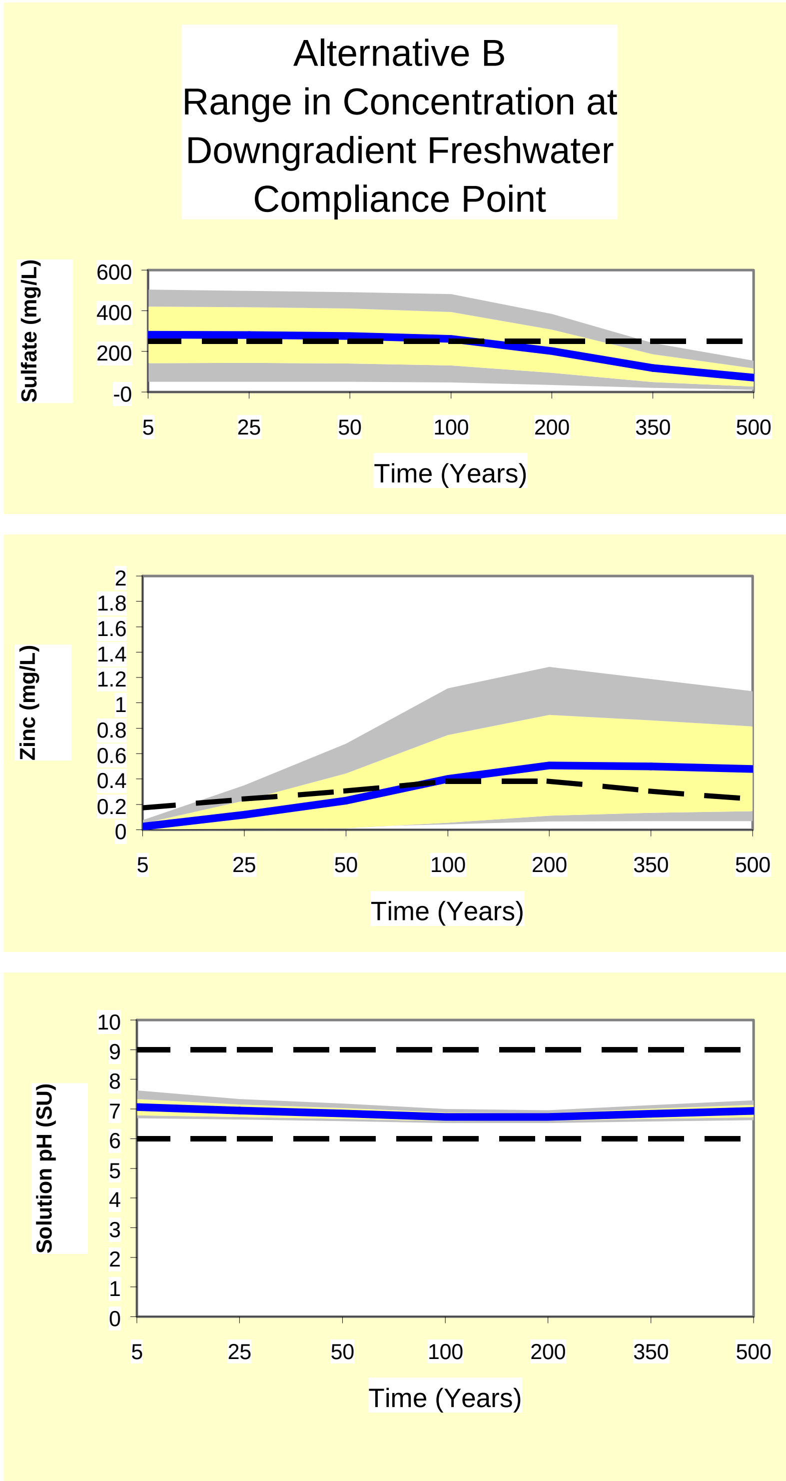

Figure 29. Alternative B - Range in concentration at compliance point.

6.2.3 Alternative C – East Ridge + Monument Values Boundary Changes + Analysis of Role of Carbon in Pile

Summary results from the mass load model for Alternative C are shown in Tables 16 and 17, and Figure 30. Results for Alternative C reflect the fundamental difference in long-term chemistry that would result from the addition of carbon to the tailings pile. As with Alternatives A and B, initially water in the underdrains without dilution (discharge scenario 1(a)) could exceed fresh water AWQS for sulfate and antimony. Sulfate concentration would decrease after 200 years to below fresh water AWQS. Elevated zinc and selenium would not occur in the underdrain water because on-going sulfate reduction tends to remove these constituents. Antimony, on the other hand, is not affected by sulfate reduction, and may increase as a result of biological reduction. The elevated antimony concentration predicted by the model is likely to be removed from solution when the water from the underdrain contacts the air causing iron and manganese compounds to chemically precipitate, adsorb antimony, and settle from solution. All of these substances are expected to meet fresh water AWQS with dilution (discharge scenario 1(b)) at the compliance point except for sulfate. Sulfate, at the compliance point using dilution, is marginally above fresh water AWQS for the first 50 to 100 years (without treatment). KGCMC will continue an appropriate method of water treatment until the tailings effluent can be discharged without treatment so that applicable AWQS are met.

Alternative C is expected to have the highest iron, manganese and sulfide levels of any of the alternatives, especially after the first 50 to 100 years. This is because sulfate reduction is expected to dominate the chemistry of tailings pore water in the long term. Low concentrations of dissolved sulfide are expected in underdrain water for all alternatives for at least 100 years due to sulfate reduction that currently occurs in the tailings. If the underdrain water is aerated or contacts the atmosphere after discharge, the sulfide is expected to rapidly oxidize. If the underdrain water is discharged into a subsurface zone, the sulfide may persist, and relevant standards for sulfide may be exceeded.

Results of the water quality model for Alternative C compared to marine water AWQS (discharge scenario 2) show there are no exceedances. The predicted load of metals was compared to the loads currently allowable under the NPDES discharge permit using a diffuser in Hawk Inlet. Predicted loads were less than 0.1 percent of allowable loads for Alternative C for all metals in the permit.

Effects to water quality in the Hawk Inlet drainage are considered *minor* (compared to *significant* for Alternatives A and B) for the case where tailings effluent is discharged directly (without treatment) to surface water or groundwater without dilution, or diluted (without treatment) with surface water or groundwater prior to discharge to receiving waters (discharge scenario 1). If water treatment were continued in perpetuity, there would be negligible adverse effects to the receiving surface water or groundwater. There would be negligible adverse effects to marine water for the case where tailings effluent is discharged directly to Hawk Inlet (discharge scenario 2). There would be negligible adverse effects for the case where tailings effluent is discharged through a diffuser into Hawk Inlet (discharge scenario 3).

Table 16. Alternative C - Predicted concentration of common ions in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative C - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS	250			6 to 9	0.050	0.0005 to 0.0005	0.254 to 0.261
5	**616**	90	7.1	162	0.010	0.0001	0.006
25	**587**	90	7.1	162	0.010	0.0001	0.006
50	**550**	90	7.1	163	0.010	0.0001	0.006
100	**483**	90	7.1	163	0.010	0.0001	0.006
200	**339**	89	7.1	162	0.010	0.0001	0.006
350	196	88	7.1	161	0.010	0.0001	0.006
500	117	87	7.1	161	0.010	0.0001	0.006
1000	41	87	7.1	162	0.010	0.0001	0.006
2500	27	87	7.1	162	0.010	0.0001	0.006
Tailings Seepage (gpm)	**15.6**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**44.3**						

Alternative C - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
Background	6	22	7.1	66	0.005	0.00004	0.0026
AWQS	250			6 to 9	0.050	0.0003 to 0.0003	0.151 to 0.153
5	**290**	48	7.0	99	0.007	0.0001	0.003
25	**277**	48	7.0	100	0.007	0.0001	0.003
50	**260**	48	7.0	100	0.007	0.0001	0.003
100	227	48	7.0	100	0.007	0.0001	0.003
200	162	49	7.0	100	0.007	0.0001	0.003
350	87	48	7.0	101	0.007	0.0001	0.003
500	52	49	7.0	101	0.007	0.0001	0.003
1000	20	49	7.0	100	0.007	0.0001	0.003
2500	15	49	7.0	100	0.007	0.0001	0.003
Downgradient GW (gpm)	**27.5**						
Downgradient SW (gpm)	**80.0**						
Total Flow (gpm)	**151.8**						

Alternative C - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS (yr 50)	NA	NA	6 to 9	NA	1.8	0.4	4.1
5	616	90	7.1	162	0.010	0.0001	0.006
25	587	90	7.1	162	0.010	0.0001	0.006
50	550	90	7.1	163	0.010	0.0001	0.006
100	483	90	7.1	163	0.010	0.0001	0.006
200	339	89	7.1	162	0.010	0.0001	0.006
350	196	88	7.1	161	0.010	0.0001	0.006
500	117	87	7.1	161	0.010	0.0001	0.006
1000	41	87	7.1	162	0.010	0.0001	0.006
2500	27	87	7.1	162	0.010	0.0001	0.006
Tailings Seepage (gpm)	**15.6**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**44.3**						

Table 17. Alternative C – Predicted concentration of trace elements in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative C - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
AWQS	0.006	0.155 to 0.160	0.0194 to 0.0199	0.0066 to 0.0069	0.00077	0.112 to 0.115	0.005	0.016 to 0.017
5	**0.013**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
25	**0.013**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
50	**0.013**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
100	**0.013**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
200	**0.012**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
350	**0.012**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
500	**0.012**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
1000	**0.012**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
2500	**0.012**	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Tailings Seepage (gpm)	***15.6***
Upwelling GW (gpm)	***28.7***
Total Flow (gpm)	***44.3***

Alternative C - Discharge/Compliance Scenario 2 Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain wter (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
Background	0.0004	0.0002	0.0002	0.0001	0.000004	0.001	0.001	0.00004
AWQS	0.006	0.094 to 0.095	0.0115 to 0.0117	0.0030 to 0.0031	0.00077	0.067 to 0.067	0.005	0.0057 to 0.0059
5	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
25	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
50	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
100	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
200	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
350	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
500	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
1000	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005
2500	0.005	0.0003	0.0007	0.0002	<0.00001	0.002	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Downgradient GW (gpm)	**27.5**
Downgradient SW (gpm)	**80.0**
Total Flow (gpm)	**151.8**

Alternative C - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver
AWQS	NA	NA	0.155	0.405	0.0470	0.410	3.550	0.095
5	0.0125	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
25	0.0125	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
50	0.0125	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
100	0.0125	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
200	0.0125	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
350	0.0124	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
500	0.0123	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
1000	0.0122	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005
2500	0.0120	0.0004	0.0013	0.0005	<0.00002	0.003	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Tailings Seepage (gpm)	***15.6***
Upwelling GW (gpm)	***28.7***
Total Flow (gpm)	***44.3***

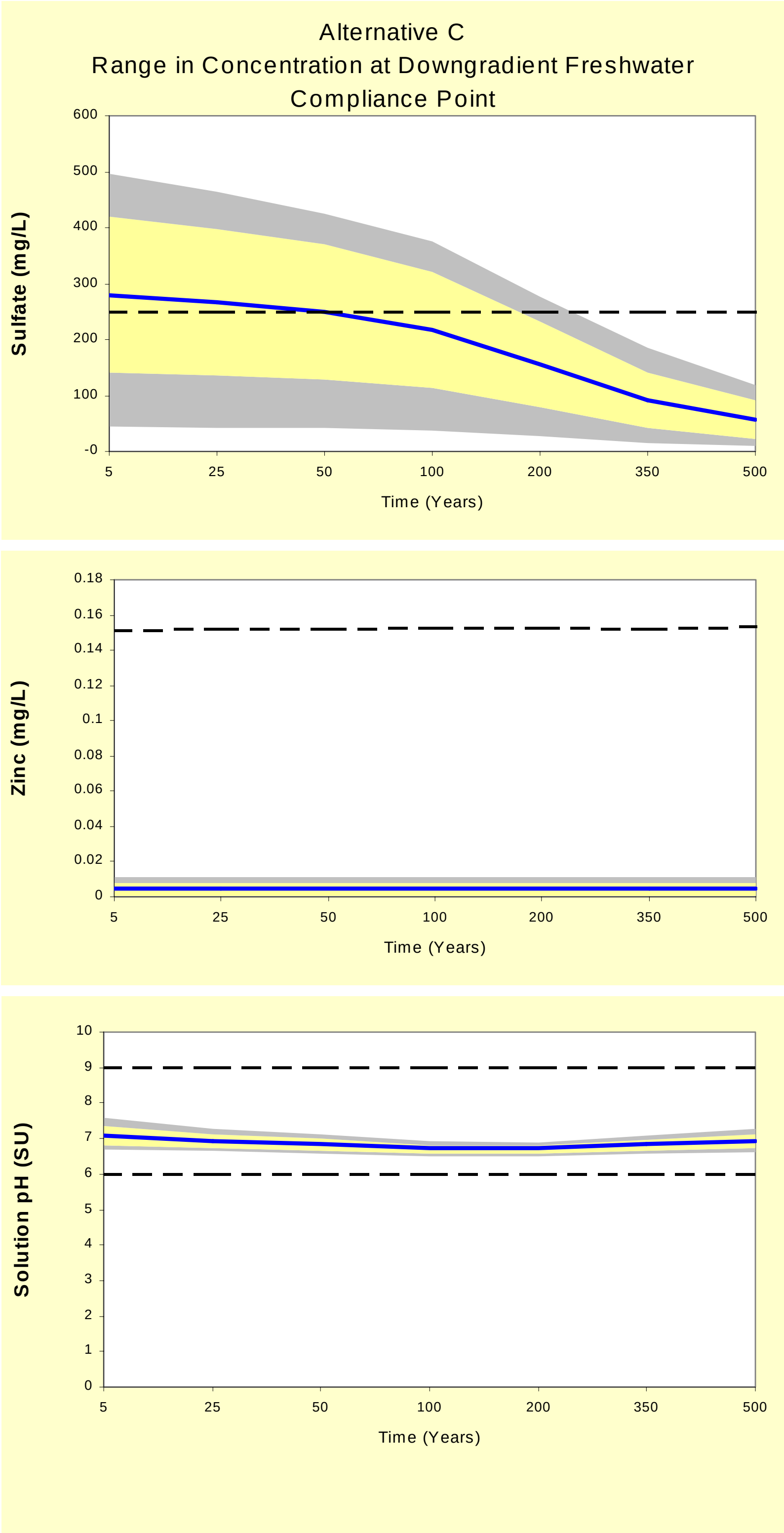

Figure 30. Alternative C - Range in concentration at compliance point.

6.2.4 Alternative D – continuous carbonate addition with expanded boundary

Results from the mass load model for Alternative D are shown in Tables 18 and 19 and Figure 31. Water quality for Alternative D is similar to that of Alternative B, with concentrations of sulfate and metals slightly higher due to the greater area of the pile. In the underdrain (without dilution, discharge scenario 1(a)), sulfate and antimony may initially exceed AWQS followed by AWQS exceedances of selenium, zinc, and cadmium after 25, 50, and 100 years, respectively. At the compliance point with dilution (discharge scenario 1(b)), sulfate and antimony initially exceed AWQS, but are predicted to be below AWQS after 200 and 25 years, respectively. Selenium, zinc, and cadmium are predicted to be above AWQS after 25, 200, and 500 years, respectively. KGCMC will continue an appropriate method of water treatment until the tailings effluent can be discharged without treatment so that applicable AWQS are met.

Results of the water quality model for Alternative D compared to marine water AWQS (discharge scenario 2) show there are no exceedances. The predicted load of metals was compared to the loads currently allowable under the NPDES discharge permit using a diffuser in Hawk Inlet. Predicted loads were less than 2 percent of allowable loads for Alternative D for all metals in the permit.

As with Alternatives A and B, effects to water quality in the Hawk Inlet drainage are considered significant for the case where tailings effluent is discharged directly (without treatment) to surface water or groundwater without dilution (discharge scenario 1(a)), or with dilution (discharge scenario 1(b)) (without treatment) with surface water or groundwater prior to discharge to receiving waters (discharge scenario 1). Effects to marine water would be negligible, the same as Alternative A, B, and C for the case where effluent is discharged directly to Hawk Inlet (without treatment or diffuser). There would be negligible adverse effects for the case where tailings effluent is discharged through a diffuser into Hawk Inlet - the same as under Alternatives A, B, and C. If water treatment were continued in perpetuity, there would be negligible adverse effects to receiving surface water, groundwater, or marine water.

Table 18. Alternative D – Predicted concentration of common ions in Underdrain flow, at a Freshwater compliance point, and at Marine discharge

Alternative D - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS	250			6 to 9	0.050	0.0005 to 0.0006	0.291 to 0.382
5	**740**	120	7.1	175	0.012	0.0001	0.046
25	**744**	198	6.9	153	0.011	0.0003	0.240
50	**733**	274	6.7	128	0.010	0.0006	**0.458**
100	**687**	410	6.6	89	0.008	**0.0010**	**0.848**
200	**518**	419	6.6	62	0.006	**0.0013**	**1.118**
350	**295**	280	6.7	62	0.006	**0.0013**	**1.143**
500	172	196	6.9	64	0.006	**0.0013**	**1.129**
1000	54	121	7.1	73	0.006	**0.0013**	**1.103**
2500	32	102	7.2	96	0.006	**0.0013**	**1.092**
Tailings Seepage (gpm)	**20.8**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**49.5**						

Alternative D - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
Background	6	22	7.1	66	0.005	0.00004	0.0025
AWQS	250			6 to 9	0.050	0.0003 to 0.0006	0.177 to 0.382
5	**348**	63	7.0	107	0.007	0.0001	0.022
25	**349**	98	6.9	96	0.007	0.0001	0.103
50	**345**	133	6.8	83	0.006	0.0002	0.198
100	**318**	193	6.7	61	0.006	0.0004	0.351
200	243	202	6.7	48	0.005	0.0006	**0.480**
350	132	139	6.8	48	0.005	0.0006	**0.491**
500	76	103	6.9	49	0.005	**0.0006**	**0.485**
1000	26	66	7.0	54	0.005	**0.0006**	**0.462**
2500	17	57	7.1	66	0.005	**0.0006**	**0.455**
Downgradient GW (gpm)	**27.5**						
Downgradient SW (gpm)	**95.5**						
Total Flow (gpm)	**172.5**						

Alternative D - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Sulfate	Calcium	pH	Bicarbonate	Arsenic	Cadmium	Zinc
AWQS	NA	NA	6 to 9	NA	1.8	0.4	4.1
5	740	120	7.1	175	0.012	0.0001	0.046
25	744	198	6.9	153	0.011	0.0003	0.240
50	733	274	6.7	128	0.010	0.0006	0.458
100	687	410	6.6	89	0.008	0.0010	0.848
200	518	419	6.6	62	0.006	0.0013	1.118
350	295	280	6.7	62	0.006	0.0013	1.143
500	172	196	6.9	64	0.006	0.0013	1.129
1000	54	121	7.1	73	0.006	0.0013	1.103
2500	32	102	7.2	96	0.006	0.0013	1.092
Tailings Seepage (gpm)	**20.8**						
Upwelling GW (gpm)	**28.7**						
Total Flow (gpm)	**49.5**						

Table 19. Alternative D – Predicted concentration of trace elements in Underdrain flow, at a Freshwater compliance point, and at Marine discharge.

Alternative D - Discharge/Compliance Scenario 1(a) Predicted Concentration in Underdrain Water
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
AWQS	0.006	0.177 to 0.231	0.0222 to 0.0293	0.0078 to 0.0109	0.00077	0.128 to 0.168	0.005	0.022 to 0.037
5	**0.015**	0.0004	0.0016	0.0006	<0.00003	0.004	0.004	<0.00005
25	**0.014**	0.0005	0.0016	0.0007	<0.00003	0.006	**0.013**	<0.00005
50	**0.013**	0.0005	0.0015	0.0008	<0.00003	0.008	**0.024**	<0.00005
100	**0.010**	0.0005	0.0015	0.0008	<0.00003	0.011	**0.041**	<0.00005
200	**0.007**	0.0006	0.0014	0.0009	<0.00003	0.013	**0.041**	<0.00005
350	**0.007**	0.0006	0.0014	0.0009	<0.00003	0.011	**0.024**	<0.00005
500	**0.007**	0.0006	0.0014	0.0009	<0.00003	0.009	**0.013**	<0.00005
1000	**0.007**	0.0006	0.0014	0.0009	<0.00003	0.007	0.003	<0.00005
2500	**0.007**	0.0006	0.0014	0.0009	<0.00003	0.007	0.002	<0.00005

Data for mercury and silver are below detection in representative contact waters

Tailings Seepage (gpm)	***20.8***
Upwelling GW (gpm)	***28.7***
Total Flow (gpm)	***49.5***

Alternative D - Discharge/Compliance Scenario 1(b) Predicted Concentration at Freshwater Compliance Location
Most probable concentration in diluted underdrain water (mg/L). Constituents that exceed chronic freshwater dissolved Alaska Water Quality Standards (AWQS) are shown in red.

Time	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver (acute)
Background	0.0004	0.0002	0.0002	0.0001	0.000004	0.001	0.001	0.00004
AWQS	0.006	0.109 to 0.231	0.0134 to 0.0293	0.0037 to 0.0109	0.00077	0.078 to 0.168	0.005	0.0078 to 0.0374
5	**0.0061**	0.0003	0.0008	0.0003	<0.00001	0.002	0.002	<0.00005
25	0.0058	0.0003	0.0008	0.0003	<0.00001	0.003	**0.006**	<0.00005
50	0.0056	0.0003	0.0008	0.0004	<0.00001	0.004	**0.010**	<0.00005
100	0.0046	0.0004	0.0008	0.0004	<0.00001	0.006	**0.017**	<0.00005
200	0.0033	0.0004	0.0007	0.0004	<0.00001	0.006	**0.018**	<0.00005
350	0.0031	0.0004	0.0007	0.0004	<0.00001	0.006	**0.010**	<0.00005
500	0.0031	0.0004	0.0007	0.0004	<0.00001	0.005	**0.006**	<0.00005
1000	0.0031	0.0004	0.0007	0.0004	<0.00001	0.004	0.002	<0.00005
2500	0.0031	0.0004	0.0007	0.0004	<0.00001	0.004	0.001	<0.00005

Data for mercury and silver are below detection in representative contact waters

Downgradient GW (gpm)	**27.5**
Downgradient SW (gpm)	**95.5**
Total Flow (gpm)	**172.5**

Alternative D - Discharge/Compliance Scenario 2 Predicted Concentration at Marine Discharge
Most probable concentration in underdrain flow (mg/L). Constituents that exceed chronic marine Alaska Water Quality Standards (AWQS) with a 50:1 mixing zone dilution ratio are shown in red.

Time (Years)	Antimony	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver
AWQS	NA	NA	0.155	0.405	0.0470	0.410	3.550	0.095
5	0.0150	0.0004	0.0016	0.0006	<0.00003	0.004	0.004	<0.00005
25	0.0139	0.0005	0.0016	0.0007	<0.00003	0.006	0.013	<0.00005
50	0.0128	0.0005	0.0015	0.0008	<0.00003	0.008	0.024	<0.00005
100	0.0101	0.0005	0.0015	0.0008	<0.00003	0.011	0.041	<0.00005
200	0.0073	0.0006	0.0014	0.0009	<0.00003	0.013	0.041	<0.00005
350	0.0069	0.0006	0.0014	0.0009	<0.00003	0.011	0.024	<0.00005
500	0.0069	0.0006	0.0014	0.0009	<0.00003	0.009	0.013	<0.00005
1000	0.0069	0.0006	0.0014	0.0009	<0.00003	0.007	0.003	<0.00005
2500	0.0069	0.0006	0.0014	0.0009	<0.00003	0.007	0.002	<0.00005

Data for mercury and silver are below detection in representative contact waters

Tailings Seepage (gpm)	***20.8***
Upwelling GW (gpm)	***28.7***
Total Flow (gpm)	***49.5***

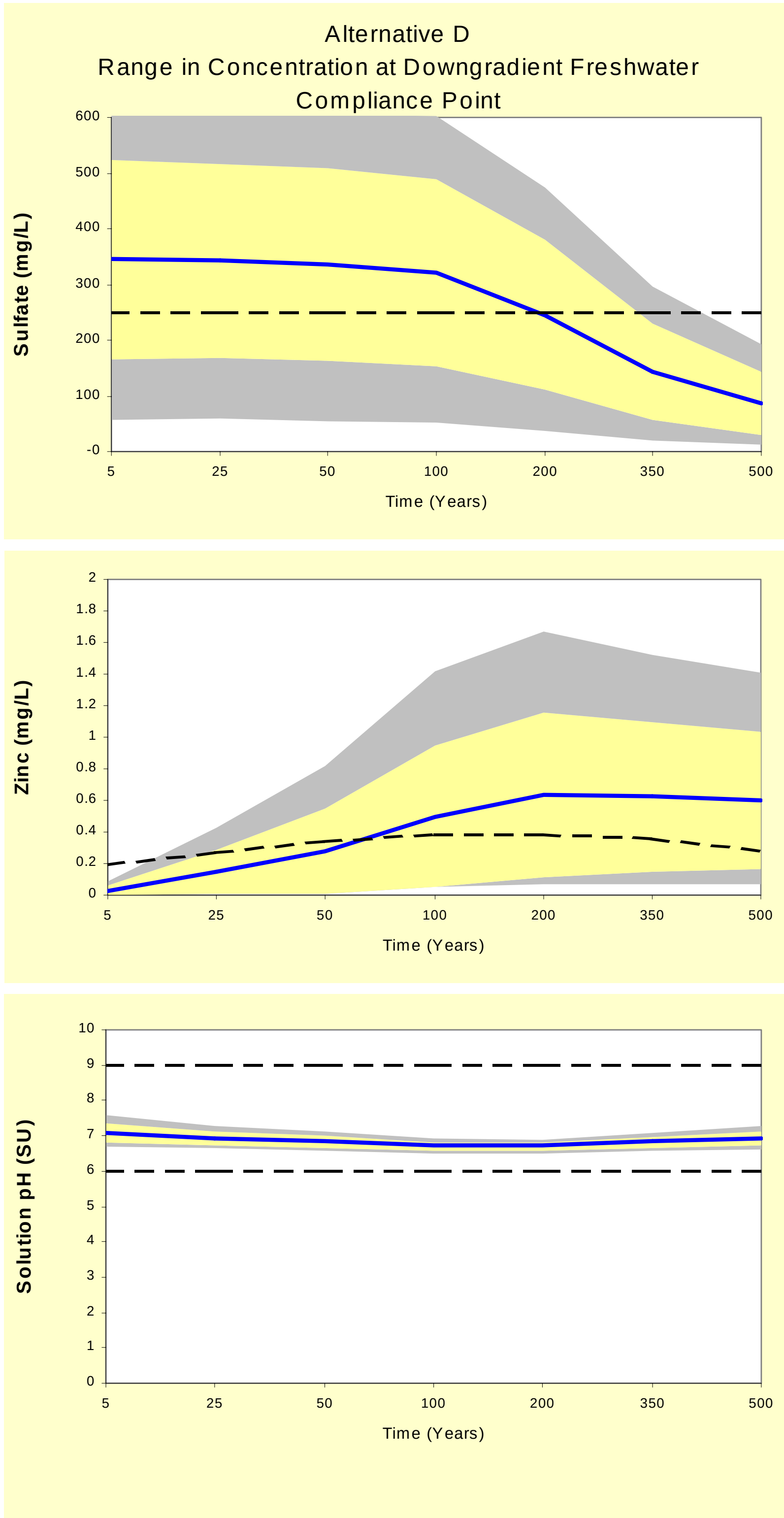

Figure 31. Alternative D - Range in concentration at compliance point.

7.0 Sensitivity Analysis

A sensitivity analysis was performed for Alternative B results for two key constituents; sulfate and zinc. The sensitivity analysis was conducted by simultaneously varying each parameter in the mass load model in a series of 1,000 iterations. Using the model results, the correlation of sulfate and zinc concentrations with other variables in the model was determined for the 25-year and the 500-year time frame.

Sulfate concentrations (year 25) in the underdrain for Alternative B began elevated and decreased through time due to the lower oxygen flux through the engineered cover (Figure 32). At 25 years, sulfate concentrations downgradient of the tailings were inversely correlated with the amount of upwelling groundwater and the amount of runoff. This is because upwelling groundwater and runoff tend to dilute the high-sulfate tailings contact water. Sulfate at 25 years was positively correlated with the sulfate concentration in the reduced tailings water and sulfate in the oxidized tailings water. This shows that the water quality in seepage was beginning to transition from reduced to oxidized zone after 25 years. Sulfate was also correlated with the rainfall and the post-closure infiltration rate, each of which affect the seepage rate.

Sulfate concentrations after 500 years are much lower than at 25 years because of the reduced oxygen flux through the engineered cover. Sulfate concentrations downgradient of the tailings (Figure 32) were inversely correlated with the amount of upwelling groundwater and the amount of runoff, because of their diluting effect. Sulfate was also inversely correlated with rainfall and the post-closure infiltration rate. Simulations with higher rainfall and infiltration cause the accumulated sulfate to be rinsed out of the tailings more quickly and thus achieve the lower equilibrium sulfate concentrations more quickly than occurs for low infiltration rates. Sulfate after 500 years was also positively correlated with the sulfate in the tailings oxidized zone indicating that the transition from the intermediate to the long-term tailings chemistry is not complete after 500 years.

Zinc concentrations for year 25 and 500 downgradient of the tailings (Figure 33) were similarly correlated with key model inputs. For both time periods, zinc was positively correlated with zinc concentration in the oxidized zone of the tailings, and with the infiltration rate. Zinc was inversely correlated with runoff and upwelling groundwater flow.

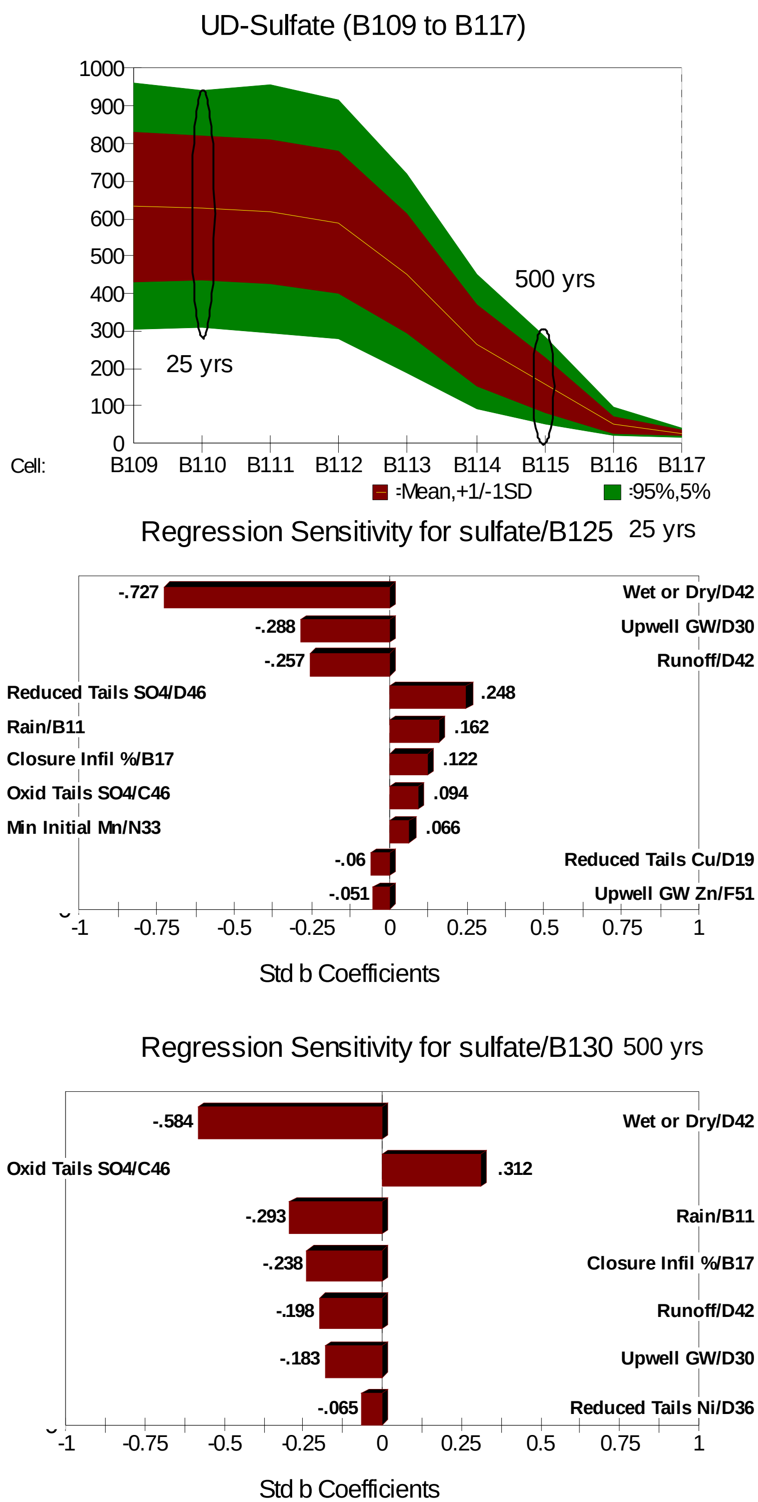

Figure 32. Sensitivity of sulfate to various mass load model input.

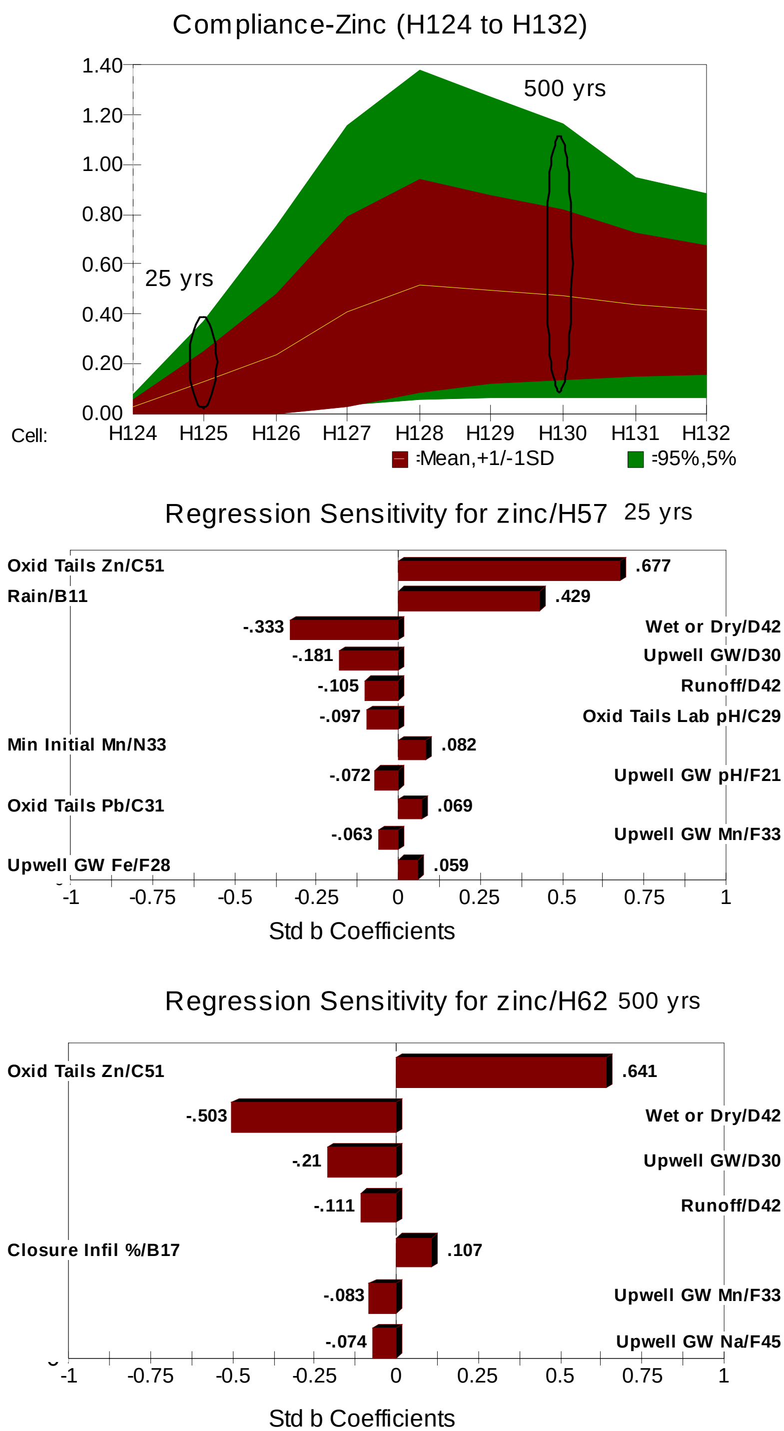

Figure 33. Sensitivity of zinc to various mass load model input.

6.3 Discussion

- Based on the model assumptions, the tailings are expected to remain alkaline for at least 500 years.
- Prediction of the rate of oxidation and acidification is inherently complex, so it is possible that acidic conditions could form in the tailings. Based on available but limited kinetic data, the risk of acidification during operations is considered small. Placement of an engineered soil cover is expected to reduce the post-closure acidification risk by greatly reducing the availability of oxygen. Appendix 3 of the General Plan of Operations requires on-going monitoring to detect incipient acidification so that mitigation measures can be developed and employed.
- The conceptual model and the model calibration each indicated that sulfate, zinc, nickel, iron manganese concentrations were somewhat higher in the drain system (or wet wells) than were predicted by the model. The likely source of the iron and manganese was from reducing conditions in or beneath the tailings. The excess sulfate, zinc and nickel are attributed to geochemical reactions occurring within the drain. The model results should better reflect actual conditions when the atmospheric connection to the drain system is blocked during closure. If the drain systems continue to provide input of these constituents after closure or if there is a different long-term source of these constituents, then the model will under predict concentrations of these constituents.
- The initial chemistry was similar (allowing for differences in the relative amount of dilution) for all alternatives because the chemistry of the first pore volume of tailings seepage is determined by the current operating conditions.
- The influence of the first pore volume of solution lasts 50 to 100 years.
- The long-term equilibrium geochemical concentrations of sulfate and metals are much lower than occurs during earlier stages (except for Alternative C which is consistently low). This is a result of the reduced rate of oxygen diffusion through the engineered cover. Geochemical equilibrium is not achieved until all secondary minerals are leached from the system, which may require hundreds of years.
- Carbonate addition is ineffective at reducing metal leaching and increases the required area of the tailings by one third, thereby increasing the tailings seepage rate.
- Maintenance of carbon at levels that support sulfate reduction processes will have a beneficial effect on the water quality of tailings seepage.
- Low concentrations of dissolved sulfide are expected in underdrain water for all alternatives for at least 100 years due to sulfate reduction that currently occurs in the tailings. Dissolved sulfide will be retained in tailings water for the long-term only in Alternative C. If the underdrain water is aerated or contacts the atmosphere after discharge, the sulfide is expected to rapidly oxidize. If the underdrain water is discharged into a subsurface zone, the sulfide may persist, and relevant standards for sulfide may be exceeded.

- Compliance with water quality standards can be achieved for each of the alternatives, though different water management strategies would be required. Discharge to marine waters or treatment would be suitable for Alternatives A, B and D. Discharge to freshwaters may be suitable for Alternative C.

7.0 References

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Appendix 1
Precipitation Data

JUNEAU AP, ALASKA
Monthly Total Precipitation (inches)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1949	0	0	0	0	0	0	0	0	7.8	8.5	9.02	2.35	
1950	0.94	2.22	1.29	2.09	3.38	1.08	7.07	4.95	7.32	3.28	2.13	3.43	39.18
1951	2.09	2.31	3.75	3.54	2.12	4.06	2.67	2.76	3.85	3.65	4.7	2.3	37.8
1952	3.5	2.85	3.32	3.72	6.05	2.44	3.71	5.9	10.63	13.29	7.11	2.86	65.38
1953	1.46	6.28	3.65	2.95	2.51	2.98	2.95	5.45	6.17	12.33	2.72	5.02	54.47
1954	2.01	4.22	1.49	1.95	2.98	1.48	3.5	1.11	5.03	6.32	5.67	5.42	41.18
1955	4.03	3.3	4.72	2.46	4.89	2.22	2.37	6.53	5.39	7.47	2.65	2.86	48.89
1956	2.83	4.05	4.69	3	4.83	3.42	2.96	9.99	4.59	6.5	11.22	9.89	67.97
1957	1.05	3.99	1.35	3.65	2.44	1.44	2.83	1.5	4.74	3.94	8.55	2.15	35.48
1958	4.9	2	1.2	1.96	4.13	2.65	4.31	4.2	5.06	9.39	4.31	7.45	51.56
1959	1.39	4.15	4.56	3.42	3.79	1.36	7.39	4.03	5.19	6.04	6.82	5.88	49.99
1960	3.86	2.05	4.84	3.13	1.52	3.51	4.31	4.77	8.47	8.95	4.97	7.39	57.77
1961	3.01	4.07	2.67	3.92	4.75	3.22	6.04	12.31	7.01	10.2	6.12	4.04	64.35
1962	6.99	0.96	5	1.99	2.85	4.75	4.75	5.21	9.75	7.39	4.03	8.16	61.83
1963	6.55	6.03	3.69	3.85	2.02	4.53	5.22	1.2	8.05	7.78	3.91	4.56	57.39
1964	1.59	8.48	4.38	4.04	4.35	3.37	6.94	3.48	2.59	7.35	4.89	5.22	55.09
1965	7.75	5.1	1.66	3.33	4.45	3.11	2.26	4.17	0	7.99	1.46	4.26	45.54
1966	4.34	3.13	6.36	2.08	6.33	1.74	3.91	6.37	8.2	6.97	4.39	4.48	58.3
1967	4.04	4.74	1.34	1.12	2.94	2.87	4.26	5.46	8.53	5.71	5.81	3.25	50.07
1968	3.25	5.3	3.85	3.25	1.45	0	0	0	0	4.6	5.34	1.9	
1969	0.94	0.68	4.17	1.74	3.38	2.41	7.88	7.54	5.44	3.77	8.69	4.36	51
1970	2.37	3.35	4.08	3.69	3.92	2.97	5.01	7.47	9.86	5.87	2.01	2.58	53.18
1971	5.56	3.93	3.33	2.44	4.3	1.74	1.67	6.89	5.36	5.8	4.38	2.97	48.37
1972	3.73	2.71	4.19	3.62	4.03	3.98	1.15	8.62	6.24	8.49	3.35	3.56	53.67
1973	4.37	3.94	3.01	2.41	4.09	2.8	3.65	6.64	4.95	6.07	1.63	2.3	45.86
1974	2.37	6.23	1.15	2.59	1.66	4.92	3.12	5.78	5.96	15.25	7.79	7.03	63.85
1975	4.1	3.76	2.17	3.04	3.59	2.48	4.96	2.78	7.25	3.55	2.83	5.81	46.32
1976	8.19	4.82	3.61	2.14	0	3.37	2.48	3.16	8.32	6.19	5.15	5.56	52.99
1977	4.59	4.56	3.31	4.02	1.56	3.47	3.19	3.03	5.57	7.14	4.58	2.16	47.18
1978	1.71	1.5	1.84	2.19	2.86	3.18	3.98	4.39	3.07	13	3.9	4.46	46.08
1979	2.19	0.91	3.98	0.98	2.45	2.74	5.44	0.56	4.89	9.06	8.36	7.73	49.29
1980	3.44	2.83	2.75	5.32	2.53	4.37	6.49	5.61	7.91	11.26	7.1	2.27	61.88
1981	4.66	2.57	1.88	2.11	3.27	2.44	4.25	6.19	11.61	6.18	6.93	2.24	54.33
1982	3.74	1.42	2.52	2.44	5.1	1.86	1.73	5.97	5.1	7.97	2.1	1.17	41.12
1983	4	1.69	0.59	2.52	5.37	2.69	3.16	9.52	6.13	4.24	1.15	0.49	41.55
1984	6.06	5.4	3.75	2.11	1.84	4.17	6.92	6.26	3.39	6.69	5.99	5.1	57.68
1985	10.13	7	4.67	3.96	4.09	4.07	3.28	3.53	0	0	0	8.33	
1986	7	3.25	6.08	0	0	2.76	2.38	6.89	2.4	12.33	5.87	6.42	
1987	3.99	3.13	2.12	2.08	2.6	6.02	2.54	4.54	8.92	10.36	7.17	5.32	58.79
1988	2.58	6.55	4.15	2.25	3.91	2.05	5.21	5.53	5.46	9.71	8.62	4.75	60.77
1989	6.77	0.07	1.33	0.87	3.44	1.1	3.81	2.82	7.29	6.37	6.23	6.78	46.88
1990	3.72	4.54	4.86	1.06	1.72	3.32	4.65	5.35	10.63	6.59	4.89	5.55	56.88
1991	4.16	6.55	4.41	4.73	4.72	3.41	4.85	9.6	15.14	8.63	9.63	9.32	85.15
1992	8.69	7.24	6.37	3.63	9.2	2.98	5.18	5.02	11.45	5.9	7.91	5.73	79.3
1993	9.11	8.09	3.5	1.94	2.19	4.92	2.25	3.2	8.44	9	11.06	7.89	71.59
1994	7.05	2.52	6.5	3.68	4.2	1.83	4.32	2.68	11.17	9.15	9.57	6.22	68.89
1995	1.94	2.76	0	2.08	2.85	3.45	4.36	5.01	7.43	6.04	2.93	4.58	43.43
1996	2.26	8.43	4.12	2.19	1.8	6.22	3.16	7.91	10.68	6.2	2.75	4.73	60.45
1997	2.73	8.17	3.91	4.41	3.25	3.51	10.36	3.93	8.26	7.85	4.63	13.61	74.62
1998	2.54	1.9	3.71	3.12	2.21	2.5	4.95	6.8	6.17	12.13	1.72	5.45	53.2
1999	8.14	2.66	2.58	7.48	5.69	2.69	4.1	6.77	10.62	12.19	5.77	10.3	78.99
2000	4.82	1.56	5.75	4.4	3.25	5.72	6.65	6.12	10.05	10.11	6.37	4.17	68.97
2001	7.43	4.4	3.33	2.19	5.19	1.65	7.26	3.66	8.37	7.8	3.62	4.49	59.39
Average	4.24	3.93	3.41	2.86	3.42	3.04	4.27	5.18	6.81	7.69	5.22	5.08	55.59

1997-50.36 "
1998-43.72"
1999-68.95"
2000-48.84"

Appendix 2
Wet Well Baseflow Separation

		Total flow			Baseflow					
Date	Rainfall (in)	Wet Well 2 (gpm)	Wet Well 3 (gpm)	Total (gpm)	Wet Well 2 Flow (gpm)	Wet Well 3 Flow (gpm)	Combined Flow (gpm)	Seepage (gpm)	Groundwater Underflow (gpm)	
02/01/01		42.4	31.3	73.8	36.2	13.1	49.3	4.9	44.4	24.4
02/02/01		47.0	25.4	72.4	36.2	25.4	61.6	4.9	56.7	10.8
02/03/01		52.6	26.1	78.8	36.2	25.4	61.6	4.9	56.7	17.2
02/04/01		42.4	19.9	62.3	36.2	25.4	61.6	4.9	56.7	0.7
02/05/01		36.7	13.7	50.3	36.7	25.4	62.1	4.9	57.2	-
02/06/01		60.8	5.9	66.7	36.7	25.4	62.1	4.9	57.2	4.6
02/09/01		59.2	3.0	62.2	45.0	3.0	48.0	4.9	43.1	14.2
02/10/01		105.8	7.8	113.7	45.0	3.0	48.0	4.9	43.1	65.7
02/12/01		127.2	7.2	134.3	45.0	7.2	52.2	4.9	47.3	82.2
02/13/01		141.3	8.3	149.7	45.0	7.2	52.2	4.9	47.3	97.5
02/14/01		108.8	9.0	117.8	45.0	7.2	52.2	4.9	47.3	65.6
02/15/01		115.1	7.2	122.3	45.0	7.2	52.2	4.9	47.3	70.1
02/16/01		101.2	6.9	108.1	45.0	7.2	52.2	4.9	47.3	56.0
02/17/01		87.8	6.9	94.7	45.0	6.9	51.9	4.9	47.1	42.8
02/18/01		71.9	7.2	79.2	45.0	6.9	51.9	4.9	47.1	27.2
02/19/01		59.9	6.8	66.7	45.0	6.8	51.8	4.9	46.9	14.9
02/20/01		19.4	6.8	26.2	45.0	6.8	51.8	4.9	46.9	-
02/21/01		13.6	7.0	20.6	45.0	6.8	51.8	4.9	46.9	-
02/22/01		14.5	8.8	23.3	45.0	6.8	51.8	4.9	46.9	-
02/23/01		32.6	9.3	41.9	45.0	6.8	51.8	4.9	46.9	-
02/24/01		141.6	8.4	150.0	45.0	6.8	51.8	4.9	46.9	98.2
02/25/01		112.6	7.8	120.3	45.0	7.8	52.8	4.9	47.9	67.6
02/26/01		159.3	10.7	170.0	45.0	7.8	52.8	4.9	47.9	117.2
02/27/01		201.5	55.7	257.2	45.0	7.8	52.8	4.9	47.9	204.4
02/28/01		270.8	30.6	301.5	45.0	7.8	52.8	4.9	47.9	248.7
03/01/01		256.9	20.1	277.0	45.0	7.8	52.8	4.9	47.9	224.2
03/02/01		254.2	16.2	270.4	45.0	7.8	52.8	4.9	47.9	217.6
03/03/01		239.6	13.8	253.3	45.0	7.8	52.8	4.9	47.9	200.6
03/04/01		238.1	11.2	249.2	45.0	7.8	52.8	4.9	47.9	196.5
03/05/01		254.9	9.8	264.7	45.0	9.8	54.8	4.9	49.9	209.9
03/06/01		237.7	10.1	247.8	45.0	9.8	54.8	4.9	49.9	193.1
03/07/01		25.0	11.9	37.0	45.0	9.8	54.8	4.9	49.9	-
03/08/01		262.7	10.9	273.6	45.0	9.8	54.8	4.9	49.9	218.8
03/09/01		251.6	10.8	262.4	45.0	10.8	55.8	4.9	51.0	206.6
03/10/01		251.7	12.0	263.8	45.0	10.8	55.8	4.9	51.0	207.9
03/11/01		258.7	18.9	277.6	45.0	10.8	55.8	4.9	51.0	221.7
03/12/01		266.7	20.1	286.8	45.0	10.8	55.8	4.9	51.0	231.0
03/13/01		271.9	15.9	287.8	45.0	10.8	55.8	4.9	51.0	232.0
03/14/01		234.0	12.4	246.5	45.0	10.8	55.8	4.9	51.0	190.6
03/15/01		229.7	11.0	240.7	45.0	11.0	56.0	4.9	51.2	184.7
03/16/01		253.8	13.5	267.4	45.0	11.0	56.0	4.9	51.2	211.3
03/17/01		256.7	15.0	271.7	45.0	11.0	56.0	4.9	51.2	215.7
03/18/01		234.8	14.9	249.7	45.0	11.0	56.0	4.9	51.2	193.7
03/19/01		122.4	11.9	134.4	45.0	11.0	56.0	4.9	51.2	78.3
03/20/01		135.1	9.9	145.0	45.0	11.0	56.0	4.9	51.2	89.0
03/21/01		178.9	8.8	187.7	45.0	11.0	56.0	4.9	51.2	131.7
03/22/01		219.0	8.1	227.1	45.0	11.0	56.0	4.9	51.2	171.0
03/23/01		217.9	7.8	225.8	45.0	11.0	56.0	4.9	51.2	169.7
03/24/01		264.5	7.8	272.3	45.0	7.8	52.8	4.9	47.9	219.5
03/25/01		369.1	7.8	376.9	45.0	7.8	52.8	4.9	47.9	324.2
03/26/01		204.7	4.1	208.8	45.0	7.8	52.8	4.9	47.9	156.0
03/27/01		8.5	-	8.5	21.9	7.8	29.7	4.9	24.8	-
03/28/01		21.3	5.2	26.5	21.9	7.8	29.7	4.9	24.8	-
03/29/01		22.6	7.2	29.8	21.9	7.8	29.7	4.9	24.8	0.1
03/30/01		23.5	7.4	30.8	21.9	7.8	29.7	4.9	24.8	1.2
03/31/01		27.6	7.6	35.2	21.9	7.8	29.7	4.9	24.8	5.6
04/01/01	0.05	27.6	7.6	35.2	21.9	7.8	29.7	4.9	24.8	5.6
04/02/01	0.00	27.8	6.8	34.7	21.9	7.8	29.7	4.9	24.8	5.0
04/03/01	0.38	26.7	6.0	32.7	21.9	7.8	29.7	4.9	24.8	3.1
04/04/01	0.17	25.7	5.5	31.2	21.9	5.5	27.4	4.9	22.5	3.8

		Total flow			Baseflow					
Date	Rainfall (in)	Wet Well 2 (gpm)	Wet Well 3 (gpm)	Total (gpm)	Wet Well 2 Flow (gpm)	Wet Well 3 Flow (gpm)	Combined Flow (gpm)	Seepage (gpm)	Groundwater Underflow (gpm)	
04/05/01	0.18	26.7	8.7	35.3	21.9	5.5	27.4	4.9	22.5	8.0
04/06/01	0.00	30.7	11.5	42.2	21.9	5.5	27.4	4.9	22.5	14.8
04/07/01	0.00	34.6	8.6	43.2	21.9	5.5	27.4	4.9	22.5	15.8
04/08/01	0.01	32.7	7.3	40.0	21.9	5.5	27.4	4.9	22.5	12.6
04/09/01	0.00	30.6	6.4	36.9	21.9	6.4	28.3	4.9	23.4	8.7
04/10/01	0.00	29.0	6.4	35.3	21.9	6.4	28.3	4.9	23.4	7.1
04/11/01	0.33	26.5	6.1	32.6	21.9	6.1	28.0	4.9	23.1	4.7
04/12/01	0.22	25.8	7.0	32.8	21.9	6.1	28.0	4.9	23.1	4.9
04/13/01	0.00	26.2	7.5	33.7	21.9	6.1	28.0	4.9	23.1	5.7
04/14/01	0.00	25.5	6.4	31.9	21.9	6.1	28.0	4.9	23.1	3.9
04/15/01	0.00	25.6	6.3	31.9	21.9	6.1	28.0	4.9	23.1	3.9
04/16/01	0.00	25.9	6.3	32.2	21.9	6.3	28.2	4.9	23.3	4.0
04/17/01	0.01	24.4	6.4	30.8	21.9	6.3	28.2	4.9	23.3	2.6
04/18/01	0.40	23.5	6.3	29.9	21.9	6.3	28.2	4.9	23.3	1.7
04/19/01	0.00	21.9	6.2	28.1	21.9	6.3	28.2	4.9	23.3	-
04/20/01	0.00	22.7	5.7	28.4	21.9	6.3	28.2	4.9	23.3	0.2
04/21/01	0.01	22.6	5.6	28.2	22.6	6.3	28.9	4.9	24.0	-
04/22/01	0.19	22.6	5.6	28.1	22.6	5.6	28.1	4.9	23.3	-
04/23/01	0.10	21.2	5.6	26.7	22.6	5.6	28.1	4.9	23.3	-
04/24/01	0.10	21.7	5.7	27.4	22.6	5.6	28.1	4.9	23.3	-
04/25/01	0.34	21.2	5.7	26.9	22.6	5.7	28.3	4.9	23.4	-
04/26/01	0.15	20.8	6.0	26.8	22.6	5.7	28.3	4.9	23.4	-
04/27/01	0.44	21.3	9.5	30.8	22.6	5.7	28.3	4.9	23.4	2.5
04/28/01	0.04	26.7	10.8	37.5	22.6	5.7	28.3	4.9	23.4	9.2
04/29/01	0.03	29.7	8.5	38.2	22.6	5.7	28.3	4.9	23.4	9.9
04/30/01	0.00	30.5	7.0	37.5	22.6	5.7	28.3	4.9	23.4	9.2
05/01/01	0.10	28.3	6.0	34.3	22.6	5.7	28.3	4.9	23.4	6.0
05/02/01	0.26	25.6	5.7	31.3	25.6	5.7	31.3	4.9	26.4	-
05/03/01	0.32	26.3	9.0	35.3	25.6	5.7	31.3	4.9	26.4	4.0
05/04/01	0.56	28.5	15.1	43.7	25.6	5.7	31.3	4.9	26.4	12.4
05/05/01	0.00	36.4	13.8	50.2	25.6	5.7	31.3	4.9	26.4	18.9
05/06/01	0.00	37.6	9.0	46.6	25.6	5.7	31.3	4.9	26.4	15.3
05/07/01	0.17	33.7	7.6	41.3	25.6	7.6	33.2	4.9	28.3	8.1
05/08/01	0.32	31.9	8.4	40.3	25.6	7.6	33.2	4.9	28.3	7.1
05/09/01	0.02	30.3	8.3	38.7	25.6	7.6	33.2	4.9	28.3	5.5
05/10/01	0.00	29.9	7.8	37.8	25.6	7.8	33.5	4.9	28.6	4.3
05/11/01	0.33	29.4	8.0	37.4	25.6	7.8	33.5	4.9	28.6	4.0
05/12/01	0.10	29.0	8.9	37.9	29.0	7.8	36.9	4.9	32.0	1.0
05/13/01	0.12	29.9	9.0	39.0	29.0	7.8	36.9	4.9	32.0	2.1
05/14/01	0.00	29.2	8.4	37.6	29.0	7.8	36.9	4.9	32.0	0.7
05/15/01	0.08	29.0	7.4	36.5	24.0	7.8	31.8	4.9	27.0	4.6
05/16/01	0.07	27.5	6.9	34.4	24.0	7.8	31.8	4.9	27.0	2.5
05/17/01	0.09	26.8	6.6	33.4	24.0	7.8	31.8	4.9	27.0	1.6
05/18/01	0.03	25.6	6.4	31.9	24.0	7.8	31.8	4.9	27.0	0.1
05/19/01	0.00	24.0	6.0	30.0	24.0	7.8	31.8	4.9	27.0	-
05/20/01	0.09	24.4	5.8	30.3	24.0	5.8	29.8	4.9	25.0	0.4
05/21/01	0.10	23.3	5.8	29.2	24.0	5.8	29.8	4.9	25.0	-
05/22/01	0.27	22.1	6.2	28.3	24.0	5.8	29.8	4.9	25.0	-
05/23/01	0.05	22.9	6.0	29.0	24.0	5.8	29.8	4.9	25.0	-
05/24/01	0.00	22.6	5.6	28.2	24.0	5.8	29.8	4.9	25.0	-
05/25/01	0.00	21.9	5.2	27.1	24.0	5.2	29.2	4.9	24.3	-
05/26/01	0.00	22.0	5.8	27.8	24.0	5.2	29.2	4.9	24.3	-
05/27/01	0.03	21.0	6.0	27.0	24.0	5.2	29.2	4.9	24.3	-
05/28/01	0.00	21.9	6.0	27.8	24.0	5.2	29.2	4.9	24.3	-
05/29/01	0.16	20.8	5.8	26.6	29.0	5.2	34.2	4.9	29.4	-
05/30/01	0.02	19.6	5.4	25.0	19.6	5.4	25.0	4.9	20.1	-
05/31/01	0.16	20.8	5.4	26.2	19.6	5.4	25.0	4.9	20.1	1.2
06/01/01	0.00	19.3	5.4	24.7	19.6	5.4	25.0	4.9	20.1	-
06/02/01	0.02	18.9	5.4	24.3	19.6	5.4	25.0	4.9	20.1	-
06/03/01	0.17	19.7	5.0	24.7	19.6	5.0	24.6	4.9	19.7	0.1
06/04/01	0.01	18.1	5.0	23.1	18.1	5.0	23.1	4.9	18.2	-
06/05/01	0.19	18.8	5.0	23.8	18.1	5.0	23.1	4.9	18.2	0.8
06/06/01	0.02	18.8	4.9	23.7	18.1	4.9	22.9	4.9	18.0	0.8
06/07/01	0.03	18.5	4.9	23.4	18.1	4.9	22.9	4.9	18.0	0.5

		Total flow			Baseflow					
Date	Rainfall (in)	Wet Well 2 (gpm)	Wet Well 3 (gpm)	Total (gpm)	Wet Well 2 Flow (gpm)	Wet Well 3 Flow (gpm)	Combined Flow (gpm)	Seepage (gpm)	Groundwater Underflow (gpm)	
06/08/01	0.00	16.7	4.4	21.2	16.7	4.4	21.2	4.9	16.3	-
06/09/01	0.13	18.1	5.0	23.1	16.7	4.4	21.2	4.9	16.3	1.9
06/10/01	0.31	19.0	5.4	24.4	16.7	4.4	21.2	4.9	16.3	3.2
06/11/01	0.00	17.8	5.2	23.1	17.8	5.2	23.1	4.9	18.2	-
06/12/01	0.00	19.2	5.2	24.4	17.8	5.2	23.1	4.9	18.2	1.4
06/13/01	0.10	19.0	5.2	24.2	17.8	5.2	23.1	4.9	18.2	1.1
06/14/01	0.01	17.8	4.8	22.6	17.8	4.8	22.6	4.9	17.8	-
06/15/01	0.12	19.1	4.9	24.0	17.8	4.8	22.6	4.9	17.8	1.3
06/16/01	0.00	18.1	4.4	22.6	17.8	4.4	22.3	4.9	17.4	0.3
06/17/01	0.00	18.3	4.4	22.8	17.8	4.4	22.3	4.9	17.4	0.5
06/18/01	0.00	18.3	4.4	22.7	17.8	4.4	22.3	4.9	17.4	0.4
06/19/01	0.01	18.2	4.4	22.6	17.8	4.4	22.3	4.9	17.4	0.3
06/20/01	0.14	18.3	4.7	23.0	17.8	4.4	22.3	4.9	17.4	0.7
06/21/01	0.14	17.7	4.2	21.9	17.8	4.2	22.1	4.9	17.2	-
06/22/01	0.04	16.9	4.4	21.3	17.8	4.2	22.1	4.9	17.2	-
06/23/01	0.23	17.8	4.4	22.2	17.8	4.2	22.1	4.9	17.2	0.1
06/24/01	0.00	17.5	4.4	21.9	17.8	4.4	22.2	4.9	17.4	-
06/25/01	0.00	18.1	4.4	22.5	17.8	4.4	22.2	4.9	17.4	0.3
06/26/01	0.00	17.4	4.3	21.7	17.8	4.3	22.2	4.9	17.3	-
06/27/01	0.00	17.5	4.3	21.8	17.8	4.3	22.2	4.9	17.3	-
06/28/01	0.19	17.5	4.1	21.6	17.8	4.1	21.9	4.9	17.1	-
06/29/01	0.00	16.5	4.1	20.6	17.8	4.1	21.9	4.9	17.1	-
06/30/01	0.00	16.2	4.1	20.3	17.8	4.1	21.9	4.9	17.1	-
07/01/01	0.00	16.5	3.9	20.3	17.8	3.9	21.7	4.9	16.9	-
07/02/01	0.00	15.3	4.1	19.4	17.8	3.9	21.7	4.9	16.9	-
07/03/01	0.02	15.2	4.0	19.2	17.8	4.0	21.8	4.9	16.9	-
07/04/01	0.10	14.2	4.1	18.3	14.2	4.0	18.1	4.9	13.3	0.1
07/05/01	0.52	15.3	4.5	19.9	14.2	4.0	18.1	4.9	13.3	1.7
07/06/01	0.25	14.9	5.7	20.6	14.2	4.0	18.1	4.9	13.3	2.4
07/07/01	0.32	15.7	7.2	22.8	14.2	4.0	18.1	4.9	13.3	4.7
07/08/01	0.11	18.6	7.4	26.0	14.2	4.0	18.1	4.9	13.3	7.8
07/09/01	0.32	21.9	7.5	29.4	14.2	4.0	18.1	4.9	13.3	11.3
07/10/01	0.06	27.4	8.1	35.5	14.2	4.0	18.1	4.9	13.3	17.4
07/11/01	0.05	29.1	6.5	35.6	14.2	4.0	18.1	4.9	13.3	17.5
07/12/01	0.14	27.3	5.7	33.0	14.2	5.7	19.9	4.9	15.0	13.1
07/13/01	0.16	26.4	6.1	32.5	14.2	5.7	19.9	4.9	15.0	12.6
07/14/01	0.14	25.7	8.3	34.0	14.2	5.7	19.9	4.9	15.0	14.2
07/15/01	0.00	27.2	6.9	34.1	14.2	5.7	19.9	4.9	15.0	14.2
07/16/01	0.04	26.5	5.9	32.4	14.2	5.7	19.9	4.9	15.0	12.6
07/17/01	0.00	25.8	5.5	31.3	14.2	5.7	19.9	4.9	15.0	11.5
07/18/01	0.00	25.1	5.0	30.1	14.2	5.7	19.9	4.9	15.0	10.3
07/19/01	0.00	24.0	4.9	28.9	14.2	5.7	19.9	4.9	15.0	9.0
07/20/01	0.00	23.2	4.9	28.1	14.2	5.7	19.9	4.9	15.0	8.3
07/21/01	0.00	21.3	4.8	26.0	14.2	4.8	19.0	4.9	14.1	7.1
07/22/01	0.44	22.2	5.1	27.4	14.2	4.8	19.0	4.9	14.1	8.4
07/23/01	0.06	20.8	5.0	25.8	14.2	5.0	19.2	4.9	14.3	6.7
07/24/01	0.26	20.5	5.0	25.5	20.5	5.0	25.5	4.9	20.6	-
07/25/01	0.06	20.6	5.0	25.6	20.5	5.0	25.5	4.9	20.6	0.1
07/26/01	0.00	21.8	5.0	26.8	20.5	5.0	25.5	4.9	20.6	1.3
07/27/01	0.00	21.7	5.0	26.7	21.7	5.0	26.7	4.9	21.8	-
07/28/01	0.07	22.4	4.8	27.2	21.7	5.0	26.7	4.9	21.8	0.5
07/29/01	0.04	21.7	4.6	26.3	21.7	4.6	26.3	4.9	21.4	-
07/30/01	0.01	21.3	4.8	26.1	21.7	4.6	26.3	4.9	21.4	-
07/31/01	0.07	21.1	4.6	25.7	21.7	4.6	26.3	4.9	21.4	-
08/01/01	0.02	21.0	4.6	25.6	21.7	4.6	26.3	4.9	21.4	-
08/02/01	0.00	20.2	4.4	24.7	21.7	4.4	26.1	4.9	21.2	-
08/03/01	0.00	19.3	4.6	23.9	19.3	4.4	23.8	4.9	18.9	0.1
08/04/01	0.31	19.5	4.4	24.0	19.3	4.4	23.8	4.9	18.9	0.2
08/05/01	0.00	18.8	4.4	23.2	19.3	4.4	23.8	4.9	18.9	-
08/06/01	0.00	18.0	4.4	22.4	19.3	4.4	23.8	4.9	18.9	-
08/07/01	0.00	17.3	4.0	21.3	19.3	4.4	23.8	4.9	18.9	-
08/08/01	0.00	16.9	3.8	20.8	19.3	3.8	23.1	4.9	18.3	-
08/09/01	0.00	16.4	4.0	20.4	16.4	3.8	20.2	4.9	15.3	0.2
08/10/01	0.00	16.4	4.2	20.6	16.4	3.8	20.2	4.9	15.3	0.4

		Total flow			Baseflow					
Date	Rainfall (in)	Wet Well 2 (gpm)	Wet Well 3 (gpm)	Total (gpm)	Wet Well 2 Flow (gpm)	Wet Well 3 Flow (gpm)	Combined Flow (gpm)	Seepage (gpm)	Groundwater Underflow (gpm)	
08/11/01	0.00	15.4	4.0	19.4	15.4	4.0	19.4	4.9	14.6	-
08/12/01	0.00	16.0	4.0	20.1	15.4	4.0	19.4	4.9	14.6	0.6
08/13/01	0.00	15.6	4.1	19.7	15.4	4.0	19.4	4.9	14.6	0.2
08/14/01	0.00	14.9	4.1	19.0	15.4	4.0	19.4	4.9	14.6	-
08/15/01	0.00	14.5	3.9	18.4	15.4	4.0	19.4	4.9	14.6	-
08/16/01	0.00	13.8	3.9	17.6	13.8	3.9	17.6	4.9	12.8	-
08/17/01	0.00	14.9	3.9	18.8	13.8	3.9	17.6	4.9	12.8	1.1
08/18/01	0.19	13.9	3.9	17.8	13.8	3.9	17.6	4.9	12.8	0.1
08/19/01	0.02	13.8	3.9	17.7	13.8	3.9	17.6	4.9	12.8	0.1
08/20/01	0.18	13.4	4.2	17.6	13.4	3.9	17.3	4.9	12.4	0.3
08/21/01	0.17	13.6	4.4	18.0	13.4	3.9	17.3	4.9	12.4	0.7
08/22/01	0.03	13.1	4.2	17.3	13.4	4.2	17.6	4.9	12.7	-
08/23/01	0.08	13.1	4.2	17.2	13.4	4.2	17.6	4.9	12.7	-
08/24/01	0.03	12.8	4.2	16.9	12.8	4.2	16.9	4.9	12.1	-
08/25/01	0.19	12.8	3.8	16.5	12.8	3.8	16.5	4.9	11.7	-
08/26/01	0.53	12.7	4.7	17.4	12.7	3.8	16.5	4.9	11.6	0.9
08/27/01	0.80	39.7	48.0	87.7	12.7	3.8	16.5	4.9	11.6	71.3
08/28/01	0.07	36.5	10.0	46.5	12.7	3.8	16.5	4.9	11.6	30.1
08/29/01	0.29	30.6	8.6	39.2	12.7	3.8	16.5	4.9	11.6	22.8
08/30/01	0.07	29.4	7.5	36.9	12.7	3.8	16.5	4.9	11.6	20.5
08/31/01	0.10	25.8	6.4	32.2	12.7	3.8	16.5	4.9	11.6	15.8
09/01/01	0.32	24.9	6.1	31.0	24.9	6.1	31.0	4.9	26.1	-
09/02/01	0.35	43.2	22.9	66.1	24.9	6.1	31.0	4.9	26.1	35.1
09/03/01	0.29	37.4	10.8	48.2	24.9	6.1	31.0	4.9	26.1	17.2
09/04/01	0.01	33.4	9.0	42.4	24.9	9.0	33.9	4.9	29.0	8.5
09/05/01	0.27	29.9	10.7	40.6	29.9	9.0	39.0	4.9	34.1	1.7
09/06/01	0.03	33.1	10.1	43.3	29.9	10.1	40.1	4.9	35.2	3.2
09/07/01	0.63	43.3	20.4	63.7	29.9	10.1	40.1	4.9	35.2	23.6
09/08/01	0.13	44.0	16.0	60.1	29.9	10.1	40.1	4.9	35.2	20.0
09/09/01	0	39.9	10.0	49.9	29.9	10.1	40.1	4.9	35.2	9.8
09/10/01	0	32.4	6.8	39.2	29.9	10.1	40.1	4.9	35.2	-
09/11/01	0.01	18.1	5.6	23.6	18.1	5.6	23.6	4.9	18.7	-
09/12/01	0.78	23.6	7.7	31.3	18.1	5.6	23.6	4.9	18.7	7.7
09/13/01	1.4	104.7	61.9	166.7	18.1	5.6	23.6	4.9	18.7	143.1
09/14/01	0.04	103.2	20.3	123.5	18.1	5.6	23.6	4.9	18.7	99.9
09/15/01	0.5	72.2	11.6	83.8	45.0	11.6	56.6	4.9	51.7	27.2
09/16/01				-	45.0	11.6	56.6	4.9	51.7	-
09/17/01				-	45.0	11.6	56.6	4.9	51.7	-
09/18/01		160.7	31.2	191.9	45.0	11.6	56.6	4.9	51.7	135.3
09/19/01		68.5	10.4	79.0	45.0	10.4	55.4	4.9	50.5	23.5
09/20/01		74.6	15.5	90.1	45.0	10.4	55.4	4.9	50.5	34.7
09/21/01		61.3	11.4	72.7	45.0	11.4	56.4	4.9	51.5	16.3
09/22/01		58.8	14.5	73.3	45.0	11.4	56.4	4.9	51.5	16.9
09/23/01		48.0	13.1	61.1	30.0	11.4	41.4	4.9	36.5	19.7
09/24/01		40.3	10.1	50.4	30.0	11.4	41.4	4.9	36.5	9.0
09/25/01		33.7	8.3	42.0	30.0	11.4	41.4	4.9	36.5	0.6
09/26/01		30.0	7.3	37.3	30.0	11.4	41.4	4.9	36.5	-
09/27/01		28.0	6.8	34.8	30.0	11.4	41.4	4.9	36.5	-
09/28/01		26.3	6.4	32.6	30.0	6.4	36.4	4.9	31.5	-
09/29/01		25.1	6.4	31.5	25.1	6.4	31.5	4.9	26.6	-
09/30/01		44.3	18.1	62.4	25.1	6.4	31.5	4.9	26.6	30.9
10/01/01		72.2	25.1	97.3	25.1	6.4	31.5	4.9	26.6	65.8
10/02/01		59.2	14.6	73.8	25.1	6.4	31.5	4.9	26.6	42.4
10/03/01		45.8	10.1	55.8	25.1	6.4	31.5	4.9	26.6	24.4
10/04/01		37.7	8.3	46.0	25.1	6.4	31.5	4.9	26.6	14.6
10/05/01		32.2	7.6	39.8	25.1	7.6	32.7	4.9	27.8	7.1
10/06/01		29.4	7.9	37.2	25.1	7.6	32.7	4.9	27.8	4.5
10/07/01		28.9	8.5	37.4	28.9	7.6	36.5	4.9	31.7	0.8
10/08/01		29.4	10.1	39.5	28.9	7.6	36.5	4.9	31.7	3.0
10/09/01		31.3	11.1	42.4	28.9	7.6	36.5	4.9	31.7	5.8
10/10/01		32.8	12.1	44.9	28.9	7.6	36.5	4.9	31.7	8.3
10/11/01		34.4	12.2	46.7	28.9	7.6	36.5	4.9	31.7	10.1
10/12/01		40.6	18.5	59.2	28.9	7.6	36.5	4.9	31.7	22.6
10/13/01		46.9	12.4	59.2	28.9	7.6	36.5	4.9	31.7	22.7

		Total flow			Baseflow					
Date	Rainfall (in)	Wet Well 2 (gpm)	Wet Well 3 (gpm)	Total (gpm)	Wet Well 2 Flow (gpm)	Wet Well 3 Flow (gpm)	Combined Flow (gpm)	Seepage (gpm)	Groundwater Underflow (gpm)	
10/14/01		39.8	9.2	49.0	28.9	9.2	38.1	4.9	33.3	10.9
10/15/01		35.4	10.2	45.6	35.4	9.2	44.7	4.9	39.8	1.0
10/16/01		37.8	17.7	55.5	35.4	9.2	44.7	4.9	39.8	10.8
10/17/01		50.9	4.2	55.1	35.4	9.2	44.7	4.9	39.8	10.4
10/18/01		53.8	3.7	57.4	35.4	3.7	39.1	4.9	34.2	18.3
10/19/01		71.9	16.0	88.0	35.4	3.7	39.1	4.9	34.2	48.9
10/20/01		64.8	13.1	77.9	35.4	3.7	39.1	4.9	34.2	38.8
10/21/01		52.1	12.4	64.5	35.4	12.4	47.9	4.9	43.0	16.7
10/22/01		46.8	12.5	59.3	35.4	12.4	47.9	4.9	43.0	11.5
10/23/01		42.4	10.8	53.1	42.4	10.8	53.1	4.9	48.2	-
Average				**62.5**			**33.5**	**4.9**	**28.6**	**30.3**

NOTE: Figures highlighted in yellow are estimates.

Appendix 3 – Tailings Saturated Zone Data

Parameter		Samples Cited in PDEIS			New Lab Data Provided by KGCMC					New Field Data Provided by KGCMC				
		PZ-T-00-1	PZ-T-00-3	MW-TB2	MW-TB2	PZ-T-00-1	PZ-T-00-2	PZ-T-00-3		PZ-T-00-01	PZ-T-00-02	PZ-T-00-03	PZ-T-00-03	MW-
Concentration					MW-T-B2	(PZAT-1)	(PZAT-2)	(PZAT-3)	DTW (feet)	60.86	59.42	nm	53.8	
	Units	5/9/2001	5/9/2001	4/25/2001	4/24/2002	5/30/2002	5/30/2002	5/30/2002		1/30/2003	1/30/2003	7/17/2001	1/30/2003	7/1
General Chemistry														
Field Temp	C	8.1	6.3	7						8.2	6.7	11.2	5.9	
Field pH	s.u.	8.14	8.15	7.71						7.6	7.9	7.4	7.3	
Field Spec. Cond.	uS/cm	3660	3510	2950						2980	3620	3020	3640	
Redox potential	mv									-300	-233	-261	-256	
Lab pH	s.u.	8.02	7.79	7.79	7.71	8.39	8.14	7.84						
Lab Spec. Cond.	uS/cm	3380	3240	3240	3590	2860	2880	3000						
TDS	mg/l	3100	2800	2700	3380	2370	2390	2590						
TSS	mg/l	<4.0	<4.0	80	8410	131	25.5	14.2						
Acidity	mg/l $CaCO_3$	<10.0	<10.0	<10.0	-10	-10	-10	-10						
Total Alkalinity	mg/l $CaCO_3$	290	340	357	472	335	247	297		>240	>240	>240	>240	
Hardness	mg/l	2750	2320	1760	2240	1760	1450	1730						
Major Cations														
Calcium	mg/l, dissolved	358	225	182	227	227	108	163						
Magnesium	mg/l, dissolved	373	355	316	401	286	282	317						
Sodium	mg/l, dissolved	133	188	129	0.148	151	192	127						
Potassium	mg/l, dissolved	45.5	53.5	43.8	42.6	41.7	38.8	49.1						
Ammonia as N	mg/l, dissolved					9.33	13.5	16.3						
Ammonium as N	mg/l, dissolved				15.2	8.31	12.6	15.7						
Major Anions														
Bicarb Alkalinity	mg/l $CaCO_3$	290	340	357										
Carb Alkalinity	mg/l $CaCO_3$	<5.0	<5.0	<5.0										
Bicarbonate as HCO3	mg/l				287	327	244	295						
Carbonate as CO3	mg/l					7.73	2.89	1.75						
Sulfate	mg/l	1980	1790	1820	2000	1370	1500	1560						
Sulfide	mg/l	13	0.0625	7.0	-0.002	0.16	0.05	0.06		>5	>5	>5	>5	
Boron	mg/l, dissolved	0.224	0.166	0.11										
Chloride	mg/l	22	35.9	15.8	12.6	27.6	22.7	28.4						
Fluoride	mg/l	0.375	0.563	0.46										
Nitrate-N	mg/l as N	<0.1	0.833	0.25	-1.2	-2	-2	-2						
Nitrite-N	mg/l	<0.1	<0.1	<0.1										
Orthophosphate	mg/l	0.0487	0.0354	0.00216										
Phosphorus	mg/l	0.238	0.159	0.589	4.64	0.621	0.407	0.424						
DOC	mg/l	44	20	33.4	22	15	6	7						
Trace Metals														
Aluminum	mg/l, dissolved	0.364	0.263	0.287	0.00915	0.0252	0.0196	0.0118						
Antimony	mg/l, dissolved	0.00385	0.0129	0.00391	0.11	0.0083	0.00418	0.00157						
Arsenic	mg/l, dissolved	0.0108	0.0114	0.0168	0.0922	0.0265	0.022	0.027						
Barium	mg/l, dissolved	0.0129	0.0136	0.0117	0.0116	0.017	0.0185	0.0201						
Cadmium	mg/l, dissolved	<0.0001	<0.0001	<0.0001	-0.0002	-0.0002	-0.0002	-0.0002						
Chromium	mg/l, dissolved	<0.0005	<0.0005	0.00097	-0.00015	0.000897	0.000899	0.00123						
Copper	mg/l, dissolved	0.00578	0.00576	0.00309	0.000469	0.00237	0.00361	0.00219						
Iron	mg/l, dissolved	<0.1	0.15	<0.1	0.142	-0.05	-0.05	0.252		0	0	0	0	
Lead	mg/l, dissolved	<0.0002	<0.0002	<0.0002	0.0037	0.00125	0.000919	0.00068						
Manganese	mg/l, dissolved	0.453	0.899	0.335	0.271	0.291	0.135	0.369						
Mercury	mg/l, dissolved	<0.00001	<0.00001	<0.00001	-0.0002	-0.0002	-0.0002	-0.0002						
Molybdenum	mg/l, dissolved	0.00828	0.872	<0.005	0.0223	0.00157	0.0353	0.019						
Nickel	mg/l, dissolved	0.00159	0.00185	0.00151	0.00977	0.0138	0.00763	0.0109						
Selenium	mg/l, dissolved	0.00362	0.00253	0.00134	0.000741	0.00151	0.00307	0.01						
Silica	mg/l, dissolved	10.1	9.15	10.1	12.2	5.69	3.91	4.75						
Silver	mg/l, dissolved	0.00013	0.00015	<0.0001	0.000357	-0.0001	-0.0001	-0.0001						
Zinc	mg/l, dissolved	0.0132	0.0123	0.0109	0.00627	0.0103	0.00578	0.00557						
Cat/Anion Bal	% Difference	19.2	17.49	1.84	0.72	6.79	1.4	2.11						

Note - elements that were below detection denoted with a "<" for PDEIS samples and with a "-" for new samples
- field data for iron and sulfide have a higher limit of detection than for lab tests

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Appendix 4
Stochastic Variable Input Values
Used in the Mass Load Model

The following tables identify the stochastic values used to describe parameter distributions. Stochastic simulation software created by Palisade (@Risk version 4.0) was used to perform the probabilistic simulations. A typical @Risk function describing a log-normally distributed variable with a particular mean, standard deviation, minimum and maximum vale would take the form:

RiskLognorm(mean,sd,min,max)

Refer to the @Risk Users Manual for additional details on the following expressions.

Constituent	Units	TW-C_{ox} - Tailings Water Oxidized Zone Water
Acidity	mg/l CaCO3	5
Aluminum	mg/l, dissolved	=RiskTlognorm(0.3,0.3,0.075,1.2, RiskName("Oxid Tails Al"))
Antimony	mg/l, dissolved	=RiskTlognorm(0.0204,0.02,0.005,0.08, RiskName("Oxid Tails Sb"))
Arsenic	mg/l, dissolved	=RiskTlognorm(0.01,0.01,0.0025,0.04, RiskName("Oxid Tails As"))
Barium	mg/l, dissolved	
Bicarb Alkalinity	mg/l CaCO3	=RiskTnormal(38,10,9.5,152, RiskName("Oxid Tails HCO3"))
Boron	mg/l, dissolved	
Cadmium	mg/l, dissolved	=RiskTlognorm(0.00376,0.003,0.00094,0.015, RiskName("Oxid Tails Cd"))
Calcium	mg/l, dissolved	=RiskTnormal(1720,430,430,6880, RiskName("Oxid Tails Ca"))
Carb Alkalinity	mg/l CaCO3	
Cat/Anion Bal	% Difference	
Chloride	mg/l	=RiskTnormal(13.6,3.4,3.4,54.4, RiskName("Oxid Tails Cl"))
Chromium	mg/l, dissolved	0.001
Copper	mg/l, dissolved	=RiskTlognorm(0.00332, 0.0017958, 0.0002,0.01156, RiskName("Oxid Tails Cu"))
DOC	mg/l	
Field pH	s.u.	
Field Spec. Cond.	uS/cm	
Field Temp	C	
Flow (approximate)	gpm	
Fluoride	mg/l	
Hardness	mg/l	=RiskTnormal(1660, 530.72,531,4540, RiskName("Oxid Tails Hardness"))
Hydroxide Alk.	mg/l CaCO3	
Iron	mg/l, dissolved	=RiskTlognorm(0.192,0.19,0.048,0.768, RiskName("Oxid Tails Fe"))
Lab pH	s.u.	=-LOG10(RiskTnormal(0.000000275,0.000000138,0.00000088,0.0000011, RiskName("Oxid Tails Lab pH")))
Lab Spec. Cond.	uS/cm	
Lead	mg/l, dissolved	=RiskTlognorm(0.0025,0.0025,0.000625,0.01, RiskName("Oxid Tails Pb"))
Magnesium	mg/l, dissolved	=RiskTnormal(453,113,113,1812, RiskName("Oxid Tails Mg"))
Manganese	mg/l, dissolved	=RiskTlognorm(1.81,1.8,0.45,7.24, RiskName("Oxid Tails Mn"))
Mercury	mg/l, dissolved	0.00005
Molybdenum	mg/l, dissolved	
Nickel	mg/l, dissolved	=RiskTlognorm(0.048,0.048,0.012,0.192, RiskName("Oxid Tails Ni"))
Nitrate-N	mg/l as N	
Nitrite-N	mg/l	
Orthophosphate	mg/l	
Phosphorus	mg/l	
Potassium	mg/l, dissolved	=RiskTnormal(66.3,16.6,16.6,265, RiskName("Oxid Tails K"))
Selenium	mg/l, dissolved	=RiskTlognorm(0.244,0.24,0.061,0.976, RiskName("Oxid Tails Se"))
Silica	mg/l	
Silver	mg/l, dissolved	0.00005
Sodium	mg/l, dissolved	=RiskTnormal(89.4,22.4,22.4,357.6, RiskName("Oxid Tails Na"))
Sulfate	mg/l	=RiskTnormal(2290,573,573,9160, RiskName("Oxid Tails SO4"))
Sulfide	mg/l	
TDS	mg/l	
Total Alkalinity	mg/l CaCO3	
TSS	mg/l	
Zinc	mg/l, dissolved	=RiskTlognorm(3.57,3.5,0.89,14.3, RiskName("Oxid Tails Zn"))

Constituent	Units	TW-C_{sr} - Tailings Water Sulfate Reduction Zone Water
Acidity	mg/l CaCO3	5
Aluminum	mg/l, dissolved	=RiskTnormal(0.13996,0.15713,0.0045,0.728, RiskName("Reduced Tails Al"))
Antimony	mg/l, dissolved	=RiskTnormal(0.020673, 0.039568,0.00078,0.22, RiskName("Reduced Tails Sb"))
Arsenic	mg/l, dissolved	=RiskExpon(0.018729, RiskShift(0.0081245), RiskName("Reduced Tails As"))
Barium	mg/l, dissolved	
Bicarb Alkalinity	mg/l CaCO3	=RiskTnormal(334, 71.279,123.5,944, RiskName("Reduced Tails HCO3"))
Boron	mg/l, dissolved	
Cadmium	mg/l, dissolved	0.00005
Calcium	mg/l, dissolved	=RiskTnormal(212.857, 77.51,54,716, RiskName("Reduced Tails Ca"))
Carb Alkalinity	mg/l CaCO3	
Cat/Anion Bal	% Difference	
Chloride	mg/l	=RiskTnormal(23.5714, 7.9113,6.3,71.8, RiskName("Reduced Tails Cl"))
Chromium	mg/l, dissolved	=RiskTnormal(0.00064943, 0.00045494,0.000025,0.00246, RiskName("ReducedTails Cr"))
Copper	mg/l, dissolved	=RiskTnormal(0.0033241, 0.0019343,0.00024,0.0115, RiskName("Reduced Tails Cu"))
DOC	mg/l	
Field pH	s.u.	
Field Spec. Cond.	uS/cm	
Field Temp	C	
Flow (approximate)	gpm	
Fluoride	mg/l	
Hardness	mg/l	=RiskTnormal(2001.43, 449.65,725,5500, RiskName("Reduced Tails Hardness"))
Hydroxide Alk.	mg/l CaCO3	
Iron	mg/l, dissolved	=RiskTnormal(0.120571, 0.070007,0.025,0.504, RiskName("Reduced Tails Fe"))
Lab pH	s.u.	=-LOG10(RiskTnormal(0.0000000124653, 0.0000000055941,0.00000000204,0.000000039, RiskName("Reduced Tails Lab pH")))
Lab Spec. Cond.	uS/cm	
Lead	mg/l, dissolved	=RiskTnormal(0.00097843, 0.0012838,0.00005,0.0074, RiskName("Reduced Tails Pb"))
Magnesium	mg/l, dissolved	=RiskTnormal(332.857, 44.838,141,802, RiskName("Reduced Tails Mg"))
Manganese	mg/l, dissolved	=RiskExpon(0.25829, RiskShift(0.098102), RiskName("Reduced Tails Mn"))
Mercury	mg/l, dissolved	0.00005
Molybdenum	mg/l, dissolved	
Nickel	mg/l, dissolved	=RiskExpon(0.0052114, RiskShift(0.00076551), RiskName("Reduced Tails Ni"))
Nitrate-N	mg/l as N	
Nitrite-N	mg/l	
Orthophosphate	mg/l	
Phosphorus	mg/l	
Potassium	mg/l, dissolved	=RiskTnormal(45, 4.9302,19.4,107, RiskName("Reduced Tails K"))
Selenium	mg/l, dissolved	=RiskExpon(0.0025177, RiskShift(0.00038133), RiskName("Reduced Tails ASe"))
Silica	mg/l	
Silver	mg/l, dissolved	0.00005
Sodium	mg/l, dissolved	=RiskTnormal(152.571, 27.159,63.5,384, RiskName("Reduced Tails Na"))
Sulfate	mg/l	=RiskTnormal(1717.14, 244.04,685,4000, RiskName("Reduced Tails SO4"))
Sulfide	mg/l	
TDS	mg/l	
Total Alkalinity	mg/l CaCO3	
TSS	mg/l	
Zinc	mg/l, dissolved	=RiskTnormal(0.0091886, 0.0032447,0.00278,0.0264, RiskName("Reduced Tails Zn"))

Constituent	Units	TW-C_{eq} Tailings Water Minimum Long-Term
Acidity	mg/l CaCO3	
Aluminum	mg/l, dissolved	
Antimony	mg/l, dissolved	
Arsenic	mg/l, dissolved	
Barium	mg/l, dissolved	
Bicarb Alkalinity	mg/l CaCO3	3.25E+02
Boron	mg/l, dissolved	
Cadmium	mg/l, dissolved	
Calcium	mg/l, dissolved	2.00E+02
Carb Alkalinity	mg/l CaCO3	
Cat/Anion Bal	% Difference	
Chloride	mg/l	
Chromium	mg/l, dissolved	
Copper	mg/l, dissolved	
DOC	mg/l	
Field pH	s.u.	
Field Spec. Cond.	uS/cm	
Field Temp	C	
Flow (approximate)	gpm	
Fluoride	mg/l	
Hardness	mg/l	4.00E+02
Hydroxide Alk.	mg/l CaCO3	
Iron	mg/l, dissolved	=3.97*RiskTnormal(15.45, 7.6085,2,22, RiskName('Min Initial Fe'))
Lab pH	s.u.	7.80E+00
Lab Spec. Cond.	uS/cm	
Lead	mg/l, dissolved	
Magnesium	mg/l, dissolved	3.25E+02
Manganese	mg/l, dissolved	=3.97*RiskExpon(2.454, RiskShift(2.9946), RiskName('Min Initial Mn'))
Mercury	mg/l, dissolved	
Molybdenum	mg/l, dissolved	
Nickel	mg/l, dissolved	
Nitrate-N	mg/l as N	
Nitrite-N	mg/l	
Orthophosphate	mg/l	
Phosphorus	mg/l	
Potassium	mg/l, dissolved	
Selenium	mg/l, dissolved	
Silica	mg/l	
Silver	mg/l, dissolved	
Sodium	mg/l, dissolved	
Sulfate	mg/l	
Sulfide	mg/l	
TDS	mg/l	
Total Alkalinity	mg/l CaCO3	
TSS	mg/l	
Zinc	mg/l, dissolved	

Constituent	Units	GW-C_{up} - Upwelling Groundwater
Acidity	mg/l CaCO3	5
Aluminum	mg/l, dissolved	0.1
Antimony	mg/l, dissolved	0.0005
Arsenic	mg/l, dissolved	0.005
Barium	mg/l, dissolved	
Bicarb Alkalinity	mg/l CaCO3	=RiskTnormal(65.12, 25.154,17.2,196.4, RiskName("Upwell GW HCO3"))
Boron	mg/l, dissolved	
Cadmium	mg/l, dissolved	0.00005
Calcium	mg/l, dissolved	=RiskTnormal(21.8833, 9.4972,6.25,72.4, RiskName("Upwell GW Ca"))
Carb Alkalinity	mg/l CaCO3	
Cat/Anion Bal	% Difference	
Chloride	mg/l	=RiskTnormal(4.07, 0.86801,1.47,10.7, RiskName("Upwell GW Cl"))
Chromium	mg/l, dissolved	0.00025
Copper	mg/l, dissolved	0.00025
DOC	mg/l	=RiskTnormal(3.888, 1.1277,1.41,11.46, RiskName("Upwell GW DOC"))
Field pH	s.u.	=-LOG10(RiskTnormal(0.00000051487, 0.00000074289,0.000000008109,0.000003319, RiskName("Upwell GW pH")))
Field Spec. Cond.	uS/cm	
Field Temp	C	
Flow (approximate)	gpm	
Fluoride	mg/l	0.05
Hardness	mg/l	=RiskTnormal(68.183, 24.799, 20.65,212, RiskName("Upwell GW Hardness"))
Hydroxide Alk.	mg/l CaCO3	2.5
Iron	mg/l, dissolved	=RiskTnormal(0.50567, 0.72583,0.005,3.82, RiskName("Upwell GW Fe"))
Lab pH	s.u.	=-LOG10(RiskTnormal(0.000000093314, 0.000000090177,0.00000000792,0.000000458, RiskName("Upwell GW Lab pH")))
Lab Spec. Cond.	uS/cm	
Lead	mg/l, dissolved	0.0001
Magnesium	mg/l, dissolved	=RiskTnormal(3.6017, 1.2117,0.745,10.2, RiskName("Upwell GW Mg"))
Manganese	mg/l, dissolved	=RiskTnormal(0.42965, 0.62253,0.0165,3.1, RiskName("Upwell GW Mn"))
Mercury	mg/l, dissolved	0.000005
Molybdenum	mg/l, dissolved	0.0025
Nickel	mg/l, dissolved	=RiskExpon(0.001838, RiskShift(0.0001324), RiskName("Upwell GW Ni"))
Nitrate-N	mg/l as N	0.01
Nitrite-N	mg/l	0.05
Orthophosphate	mg/l	
Phosphorus	mg/l	
Potassium	mg/l, dissolved	1
Selenium	mg/l, dissolved	0.001
Silica	mg/l	
Silver	mg/l, dissolved	0.00005
Sodium	mg/l, dissolved	=RiskTnormal(4.36167, 0.89365,1.395,10.44, RiskName("Upwell GW Na"))
Sulfate	mg/l	=RiskTnormal(5.315, 3.0746,1.41,21.4, RiskName("Upwell GW SO4"))
Sulfide	mg/l	0.05
TDS	mg/l	
Total Alkalinity	mg/l CaCO3	
TSS	mg/l	
Zinc	mg/l, dissolved	=RiskExpon(0.0045317, RiskShift(0.00024472), RiskName("Upwell GW Zn"))

Constituent	Units	GW-C_{down} - Downgradient Groundwater
Acidity	mg/l CaCO3	5.00E+00
Aluminum	mg/l, dissolved	1.00E-01
Antimony	mg/l, dissolved	5.00E-04
Arsenic	mg/l, dissolved	5.00E-03
Barium	mg/l, dissolved	
Bicarb Alkalinity	mg/l CaCO3	same as upwelling groundwater
Boron	mg/l, dissolved	
Cadmium	mg/l, dissolved	5.00E-05
Calcium	mg/l, dissolved	same as upwelling groundwater
Carb Alkalinity	mg/l CaCO3	
Cat/Anion Bal	% Difference	
Chloride	mg/l	same as upwelling groundwater
Chromium	mg/l, dissolved	2.50E-04
Copper	mg/l, dissolved	2.50E-04
DOC	mg/l	same as upwelling groundwater
Field pH	s.u.	same as upwelling groundwater
Field Spec. Cond.	uS/cm	
Field Temp	C	
Flow (approximate)	gpm	
Fluoride	mg/l	5.00E-02
Hardness	mg/l	same as upwelling groundwater
Hydroxide Alk.	mg/l CaCO3	2.50E+00
Iron	mg/l, dissolved	same as upwelling groundwater
Lab pH	s.u.	same as upwelling groundwater
Lab Spec. Cond.	uS/cm	
Lead	mg/l, dissolved	1.00E-04
Magnesium	mg/l, dissolved	same as upwelling groundwater
Manganese	mg/l, dissolved	same as upwelling groundwater
Mercury	mg/l, dissolved	5.00E-06
Molybdenum	mg/l, dissolved	2.50E-03
Nickel	mg/l, dissolved	same as upwelling groundwater
Nitrate-N	mg/l as N	1.00E-02
Nitrite-N	mg/l	5.00E-02
Orthophosphate	mg/l	
Phosphorus	mg/l	
Potassium	mg/l, dissolved	1.00E+00
Selenium	mg/l, dissolved	1.00E-03
Silica	mg/l	
Silver	mg/l, dissolved	5.00E-05
Sodium	mg/l, dissolved	same as upwelling groundwater
Sulfate	mg/l	same as upwelling groundwater
Sulfide	mg/l	5.00E-02
TDS	mg/l	
Total Alkalinity	mg/l CaCO3	
TSS	mg/l	
Zinc	mg/l, dissolved	same as upwelling groundwater

Constituent	Units	SW-C_{down} - Downgradient Surface Water
Acidity	mg/l CaCO3	5.00E+00
Aluminum	mg/l, dissolved	1.68E-01
Antimony	mg/l, dissolved	5.00E-05
Arsenic	mg/l, dissolved	2.50E-04
Barium	mg/l, dissolved	9.22E-03
Bicarb Alkalinity	mg/l CaCO3	8.00E+00
Boron	mg/l, dissolved	5.00E-02
Cadmium	mg/l, dissolved	5.00E-05
Calcium	mg/l, dissolved	3.99E+00
Carb Alkalinity	mg/l CaCO3	2.50E+00
Cat/Anion Bal	% Difference	2.37E+01
Chloride	mg/l	2.09E+00
Chromium	mg/l, dissolved	1.55E-02
Copper	mg/l, dissolved	4.66E-03
DOC	mg/l	7.99E+00
Field pH	s.u.	6.51E+00
Field Spec. Cond.	uS/cm	3.33E+01
Field Temp	C	5.40E+00
Flow (approximate)	gpm	1.00E+01
Fluoride	mg/l	5.00E-02
Hardness	mg/l	1.37E+01
Hydroxide Alk.	mg/l CaCO3	2.50E+00
Iron	mg/l, dissolved	5.00E-02
Lab pH	s.u.	7.67E+00
Lab Spec. Cond.	uS/cm	3.38E+01
Lead	mg/l, dissolved	1.00E-04
Magnesium	mg/l, dissolved	9.08E-01
Manganese	mg/l, dissolved	4.83E-03
Mercury	mg/l, dissolved	5.00E-06
Molybdenum	mg/l, dissolved	2.50E-03
Nickel	mg/l, dissolved	2.15E-03
Nitrate-N	mg/l as N	5.00E-02
Nitrite-N	mg/l	5.00E-02
Orthophosphate	mg/l	2.16E-03
Phosphorus	mg/l	2.50E-03
Potassium	mg/l, dissolved	5.00E-01
Selenium	mg/l, dissolved	2.50E-04
Silica	mg/l	4.23E+00
Silver	mg/l, dissolved	1.90E-04
Sodium	mg/l, dissolved	2.17E+00
Sulfate	mg/l	2.64E+00
Sulfide	mg/l	2.50E-02
TDS	mg/l	3.70E+01
Total Alkalinity	mg/l CaCO3	8.00E+00
TSS	mg/l	2.00E+00
Zinc	mg/l, dissolved	4.77E-03

Constituent	Units	$Ratio_{tot}$ - Tailings Total Metal to Sulfide
Acidity	mg/l CaCO3	
Aluminum	mg/l, dissolved	23.70%
Antimony	mg/l, dissolved	0.26%
Arsenic	mg/l, dissolved	0.49%
Barium	mg/l, dissolved	
Bicarb Alkalinity	mg/l CaCO3	12.86%
Boron	mg/l, dissolved	0.00%
Cadmium	mg/l, dissolved	0.10%
Calcium	mg/l, dissolved	65.80%
Carb Alkalinity	mg/l CaCO3	
Cat/Anion Bal	% Difference	
Chloride	mg/l	0.10%
Chromium	mg/l, dissolved	0.15%
Copper	mg/l, dissolved	1.50%
DOC	mg/l	
Field pH	s.u.	
Field Spec. Cond.	uS/cm	
Field Temp	C	
Flow (approximate)	gpm	
Fluoride	mg/l	
Hardness	mg/l	
Hydroxide Alk.	mg/l CaCO3	
Iron	mg/l, dissolved	83.22%
Lab pH	s.u.	
Lab Spec. Cond.	uS/cm	
Lead	mg/l, dissolved	9.21%
Magnesium	mg/l, dissolved	31.70%
Manganese	mg/l, dissolved	2.00%
Mercury	mg/l, dissolved	0.01%
Molybdenum	mg/l, dissolved	
Nickel	mg/l, dissolved	0.06%
Nitrate-N	mg/l as N	
Nitrite-N	mg/l	
Orthophosphate	mg/l	
Phosphorus	mg/l	
Potassium	mg/l, dissolved	
Selenium	mg/l, dissolved	0.01%
Silica	mg/l	
Silver	mg/l, dissolved	0.21%
Sodium	mg/l, dissolved	0.71%
Sulfate	mg/l	100.00%
Sulfide	mg/l	
TDS	mg/l	
Total Alkalinity	mg/l CaCO3	
TSS	mg/l	
Zinc	mg/l, dissolved	17.79%

Appendix B

Sulfate Reduction Monitoring Program Outline, 2002

SULFATE REDUCTION MONITORING PROGRAM OUTLINE

1.0 INTRODUCTION

This appendix to the Greens Creek Mine Tailings Stage II Expansion Environmental Impact Statement outlines a sulfate reduction monitoring program (SRMP) to be undertaken by KGCMC as part of Alternative C as described in the EIS. This outline provides a framework that KGCMC will use as a basis for developing a SRMP to be approved by the regulatory agencies. This outline provides a background discussion of the need for the SRMP, the plan's goals and objectives, guidelines for implementation, and the schedule for preparing the plan and meeting the plans' objectives.

2.0 BACKGROUND

Alternative C of the EIS includes an analysis of the role that carbon plays in promoting sulfate reduction processes in the tailings pile. Sulfate reduction is known to occur in the pile (EIS Appendix A), and is believed responsible for reducing levels of zinc in the saturated zone of the pile. Organic compounds are added to the tailings from various sources including flotation reagents, and wastewater bio-solids from the Cannery housing facility. Certain microorganisms that degrade these organic compounds under anaerobic conditions reduce sulfate to sulfide and produce bicarbonate. Sulfide ions may form an insoluble precipitate with many metal ions, especially iron, zinc, nickel and cadmium. If sulfate reduction can be sustained in the tailings pile, metal levels in pore water will be reduced. The lower metal levels in the pile will greatly improve the water quality of the effluent, especially after the cap has been placed and oxygen ingress has been reduced to post-closure levels (Appendix A).

Carbon addition to tailings as a means of supporting biological sulfate reduction has been evaluated, either directly or indirectly, at other mines. Three basin means of adding carbon to tailings have been described in the literature: as a carbon-rich layer in a cover, as an amendment to tailings, and as a naturally accumulating component of sediment in tailings closed with a water-cover. Tassé and others (1997) measured increases in pH, carbon dioxide, and methane and decreases in dissolved oxygen beneath a 2 m thick wood waste cover placed over the sulfide-enriched East Sullivan tailings. The site is located in northeastern Quebec. The primary advantage of the organic cover was the removal of oxygen prior to reaching the tailings. After placement of the cover the pH near the original tailings surface, which had acidified prior to cover placement, increased from 4.0 to 6.5 within 3 years. Groundwater downgradient of the site is expected to improve over about 10 years.

Elliot and others (1997) also evaluated various organic amendments for their suitability as organic covers placed over acidic tailings. Of the amendments tested (peat, lime-stabilized sewage sludge, municipal solid waste compost, and de-sulfurized tailings), the lime-stabilized sewage sludge was the most effective cover material, owing to the alkalinity that was leached from the cover into the underlying tailings. Li and others (2000) have performed extensive evaluations of tailings water covers at the Louvicort Mine in Quebec and the Falconbridge site in Ontario. Water covers were developed to reduce oxygen flux as is the case for the dry covers proposed at Kennecott. A secondary advantage of the water covers is the removal of oxygen due to decay of organic carbon in the sediments that accumulate above the tailings. Although these results are not directly applicable to Greens Creek, it does indicate that the rate of organic carbon decomposition is rapid enough to consume most of the oxygen that migrates through the water cover, which ranges from 0.4 to 2 moles $O_2/m^2/yr$, greater than the modeled oxygen flux through the soil cover at Greens Creek.

Canty (2000) demonstrated the effectiveness of adding composted animal wastes to acidic mine waters at an abandoned mine in Montana (the Lilly/Orphan Boy Mine). During baseflow periods, the treatment removes the majority of dissolved aluminum, copper and cadmium from the acidic water. Additionally, the organic material increased pH from less than 4 to near 7, and removed about one-half of the zinc. Treatment efficiencies were poor during the spring snowmelt period when flows dramatically increased, however. This application is seen as being more challenging than the Greens Creek tailings because the mine water was already acidic, and the organic substrate could not be uniformly mixed with the mine water.

In the closest analogue to the Greens Creek facility, Chtaini and others (1997) tested the use of paper mill waste as covers or additives to acidified tailings as a means of abating the release of metals and acidity. Laboratory column and field-scale tests were conducted on paper mill waste covers with and without partial incorporation of paper waste into the underlying tailings. In field test plots, the paper mill waste cover with 30 cm of incorporated paper waste increased the pH of pore water (in the amended layer) from 4.7 to 7.0, and decreased zinc levels from 162 mg/L to below instrument detection level. Similar reductions in copper, cadmium, and nickel also occurred. The applied organic wastes did not remove all of the oxygen from the system, but maintained neutral pH and low metal levels through dissolution of alkalinity in the waste, and sulfate reduction reactions.

The maximum quantity of carbon necessary to sustain sulfate reduction can be estimated on the basis of the rate of sulfide oxidation in the pile. Approximately 4.2 g of oxygen is expected to enter the pile annually for every square meter of pile exposure (after cap placement). Since 3.75 moles of oxygen are required to oxidize pyrite and 2 moles of carbon are necessary to reduce the sulfate formed by sulfate oxidation, then 0.53 moles of carbon could theoretically reduce all sulfate formed each year. This equates to consumption of about 1,700 pounds of organic carbon in a suitable form. A lesser quantity of carbon may suffice for supporting sulfate reduction since only a portion of the sulfate need be reduced to sulfide to effect water quality improvements. Ensuring that enough carbon is available to promote microorganism growth is an essential component of Alternative C. Without sufficient carbon, the microorganisms will not have a sufficient energy source to survive. Should this occur, the sulfate reduction process would eventually cease, with the metals remaining in solution and leaving the pile in the effluent. This could lead to metal loads in the effluent exceeding AWQS unless undergoing a treatment process to reduce the metal loads.

KGCMC has an approved Tailings Internal Environment Monitoring Program (TIEMP) as a component of their GPO (KGCMC, 2001a). The purpose of the TIEMP is to measure and evaluate the hydrologic and geochemical processes that occur within the tailings pile to better understand the behavior of the tailings and their potential interaction with the environment. Measurement of the changes in the quality and volume of effluent over time during operation and after capping will aid in evaluating the need for long-term treatment. Additionally the data will help in the design of post-closure water management and treatment systems, should these be

required.
The TIEMP provides specific information about:

- geochemical behavior of tailings and production rock placed in the tailings facility; and
- collection of data that allows development and calibration of a mass load model for the tailings that describes the movement of meteoric water through the pile, and the chemistry of pore fluids contained in the tailings.

The SRMP, when approved by the agencies, would become an additional component of the TIEMP.

3.0 SRMP GOALS

The major goals of the SRMP are summarized below. As the SRMP is implemented, new goals may be identified by KGCMC or the regulatory agencies that may change the goals listed.

- Continued monitoring of sulfate reduction processes within the pile. This goal is one identified in the TIEMP, and would continue during operations through post-closure of the tailings pile.
- Determine the amount of carbon required to promote sulfate reduction. This is the amount of carbon required, in combination with the post-closure cap, for the completed Stage II pile to ensure that sulfate reduction processes continue to occur at a rate sufficient to produce water quality that is comparable to that water in the existing saturated zone.
- Determine the amount of carbon within the existing pile. Also determine how much carbon will be added to the completed Stage II pile from existing carbon sources, i.e., that carbon found in tailings, in the remnants of mill reagents, and the biosolids from the Cannery.
- Determine the need for supplemental carbon addition to ensure that sulfate reduction processes continue to occur at a rate sufficient to produce water quality that is comparable to that water in the existing saturated zone. This amount is the difference between what is required and what will be available when the Stage II pile is completed. Types of carbon that may be available in the pile after completion of stage II include carbon added as process reagents in the mill, residual amounts of added biosolids, carbon contained in the original ore material, and soluble carbon formed through decomposition of vegetation established on the pile.
- If supplemental carbon is needed, determine the most suitable form of carbon to be used. Types of carbon that could be considered include a liquid form that would be dispensed periodically over time as the volume of pore water gets displaced, such as that deployed through injection wells or a type of irrigation system; or a solid form that could be added as the pile is developed or just prior to cap placement, such as bio-solids, a wood product, or coal. It will have to be shown that use of either form of carbon will not impact the geotechnical stability of the pile.
- If supplemental carbon is needed, determine the amount of additional carbon required based on the preferred form of carbon to be used.
- If additional carbon is needed, determine the best method of application, and the application rate.
- Develop a quality assurance (QA) mechanism for monitoring sulfate reduction processes and carbon addition procedures to ensure they result in appropriate saturated zone water quality. This QA would occur through the post-closure period.

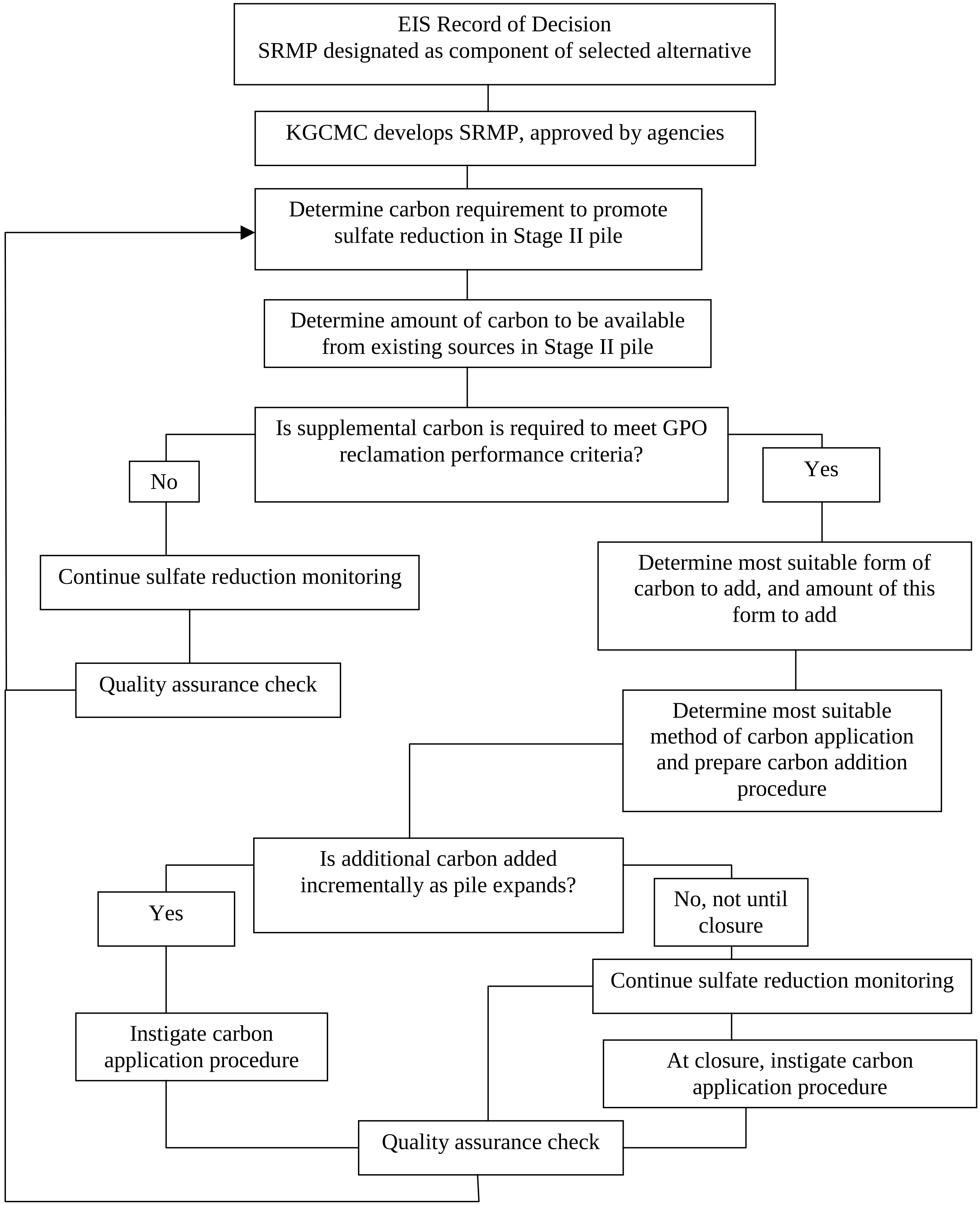
4.0 PLAN IMPLEMENTATION

A flow sheet showing an implementation plan for the SRMP that is designed to achieve the above listed goals is shown in Figure 1. The plan includes a QA plan that provides a feedback loop to assure success of the SRMP.

5.0 SCHEDULE

In Alternative C, KGCMC would continue its present method of generating and storing whole tailings during the 30 months following the issuance of the ROD for this EIS. During that 30-month period, KGCMC would prepare the SRMP, submit it to the agencies, and implement the program to the point of knowing whether or not additional carbon is required, and if required the preferred type of carbon to be used. It is also expected that within the 30-month period, the preferred carbon application method is identified and a test of the application method has been designed. The most suitable duration of the test application program will be determined by KGCMC once the most suitable type of carbon (if required) has been determined. The test application program may need to exceed the 30-month period in order to get reproducible and statistically significant results. KGCMC will advise the agencies of their test schedule and anticipated completion date once the test schedule has been prepared.

Figure 1 SRMP Implementation



Appendix C

Selected Appendices from KGCM General Plan of Operation, 2000

- General Plan Of Operations, Appendix 3 – Tailings Impoundment

- General Plan Of Operations Appendix 14 - Reclamation Plan

KENNECOTT GREENS CREEK MINING COMPANY
GENERAL PLAN OF OPERATIONS

APPENDIX 3
TAILINGS IMPOUNDMENT

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1.0 INTRODUCTION

1.1 Site History

Tailings produced by the flotation process at the Greens Creek mill are dewatered in a filter press. Some of the tailings are placed underground as backfill. The remainder of the tailings are placed on surface in a dry tailings pile. The tailings, consisting of between 73% and 96% by weight passing the No. 200 sieve, are delivered to the tailings facility by truck. The tailings moisture content when delivered are just below the optimum standard Proctor moisture content (approximately 15%). The tailings are placed into cells, spread and compacted (Klohn-Crippen 1999b).

Construction of the Kennecott Greens Creek Mine (KGCMC) tailings facility commenced in 1988 with construction of the main and saddle dams of Containment Pond No. 6, the surface water collection system, and the finger drains. The tailings have been deposited in four areas, referred to as the Old Tailings Pile, the Active Tailings Pile, the West Buttress and the East Expansion. A summary of tailings pile development from Klohn-Crippen (1999b) follows:

- Tailings placement began in early 1989 starting in the northwest comer of the Old Tailings Pile progressing south and east. In 1993, tailings placement ceased with the suspension of mining operations for a period of approximately three years. A total of approximately 735,000 yd^3 of tailings were placed in the Old Tailings Pile between 1989 and 1993.

- During the period of shutdown approximately 75,000 yd^3 of development rock was placed over the Old Tailings Pile to limit erosion during the inactive period. In August 1995, a geomembrane was placed over the Old Tailings Pile.

- The mine re-opened and tailings placement resumed in July 1996. Tailings placement started north of Containment Pond No. 6 Berm in the Active Tailings Pile located south of the Old Tailings Pile. The dry tailings placement area was expanded during this time in conjunction with changes to the water treatment system.

- Construction of a stabilizing berm (West Buttress) for the Old Tailings Pile commenced in late 1998. The construction of the main structure of the West Buttress with compacted tailings is currently on-going. The West Buttress is being raised on a prepared foundation.

- The construction of an East Expansion area commenced in 2000 to increase the capacity of the tailings facility.

1.2 Regulatory Background

1.2.1 Forest Service

The Final Environmental Impact Statement (FEIS) for the Greens Creek Project (Figure 1) was completed in 1983. Eight alternatives were identified in the FEIS with number six being selected as the preferred alternative. Under the preferred alternative, tailings generated by the milling process would be transported and disposed as slurry into a settling pond within a 150 acre tailings basin.

In 1988 two major changes were introduced by Kennecott Greens Creek Mining Company (KGCMC) regarding development and operation of the mine. The proposed changes were addressed in the 1988 Environmental Assessment for Proposed Changes to the General Plan of Operation for the Development and Operation of the Greens Creek Mine (EA). Under the EA proposed action alternative, tailings generated by the milling process would be dewatered at the mill site and transported by truck to a smaller dry tailings basin (Figure 2). Wastewater from the mill site would be transported through an eight inch, single-walled, high-density, polyethylene (HDPE) pipeline to a 3.5 acre settling pond within the tailings basin. The Greens Creek Mine Tailings Impoundment was constructed according to these guidelines consistent with the 1988 EA Decision Notice. The leased area within which the tailings facility is situated is approximately 40 acres.

The tailings facility design and operation was reviewed by Klohn-Crippen acting as consultants to KGCMC in 1998 and 1999 (Klohn-Crippen 1998, 1999a and 1999b). A West Buttress has been constructed, due to the findings of a seismic stability analysis. All design modifications and other pertinent findings of the Klohn-Crippen studies have been incorporated into this plan.

1.2.2 Solid Waste Permit

Mining wastes are categorically exempt from regulation under the Alaska solid waste program unless they pose a potential "welfare threat or environmental problem associated with the management of the waste". Recently, the state of Alaska made the determination that tailings placed in the dry tailings stack is subject to the chapter 60 solid waste requirements, which include the need to acquire a permit. Mining waste is regulated under the monofill standards 18 Alaska Administrative Code (AAC) section 60.455 which allows the department discretion to incorporate applicable provisions of 18 AAC 60 into a waste disposal permit. A waste that is not specifically addressed in Article 4 (i.e. tailings) will be classified by the ADEC and assigned the most applicable waste category.

The waste disposal permit will contain applicable provisions of Article 1 and 2 (60.010 to 60.265) that have to do with general standards, limitations, prohibitions and administrative procedures to be followed by every disposal facility regulated under the chapter. Additionally, the waste disposal permit will apply relevant locational, operational, and design related requirements from the monofill standards in Article 4 (18 AAC 60.400 to 60.495.) The monofill requirements also include closure and post-closure care deed notations, notifications, monitoring and reporting.

Furthermore, the Greens Creek facilities are subject to Article 6 (18 AAC 60.700 to 60.730) which have to do with user fees and Article 7 monitoring and corrective action requirements (18 AAC 60.800 to 60.865). In Article 7 monitoring requirements specify visual, surface water and groundwater requirements. Detection monitoring is also required under Article 7. If a significant statistical difference exists between upgradient and downgradient or if the water quality standards are exceeded in detection monitoring, then assessment monitoring will be triggered. Assessment monitoring will require the plume be identified and the owner/operator identify and implement remedial corrective measures according to 40 Code of Federal Regulations (CFR) 258.55 to 258.58. Lastly, the facilities at Greens Creek are open to waivers to any provision of the chapter under 18 AAC 60.900 upon adequate demonstration and ADEC discretion.

1.2.3 Interagency Review of Project

In 1999 and 2000 State and Federal Agencies with jurisdiction over the mine in association with KGCMC arranged a third-party assessment of the risk of acid drainage and metal release, and a review of the freshwater monitoring plan (SMI 2000). As part of their review, the third-party consultant was asked to review and revise the appendices to the General Plan of Operations relating to tailings, production rock, reclamation, and the freshwater monitoring plan (SMI 2000). This revision of Appendix 3 contains SMI modifications. Included in a separate document are Project Team comments, and a response to those comments by the third party contractor (Shepherd Miller, Inc.) who prepared this document at the request of the Project Team.

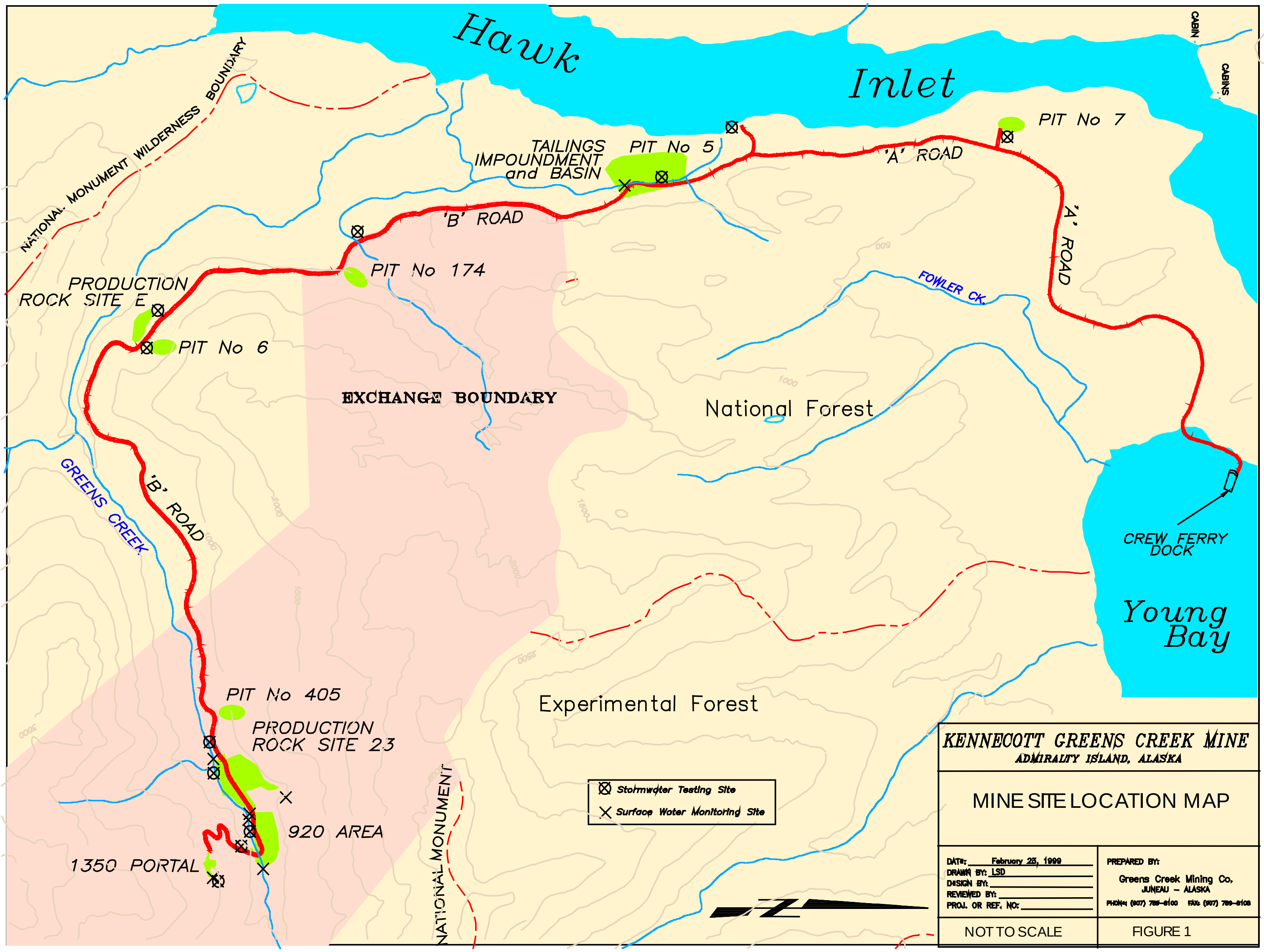

Figure 1. Location of the Kennecott Greens Creek Mine on Admiralty Island, Alaska

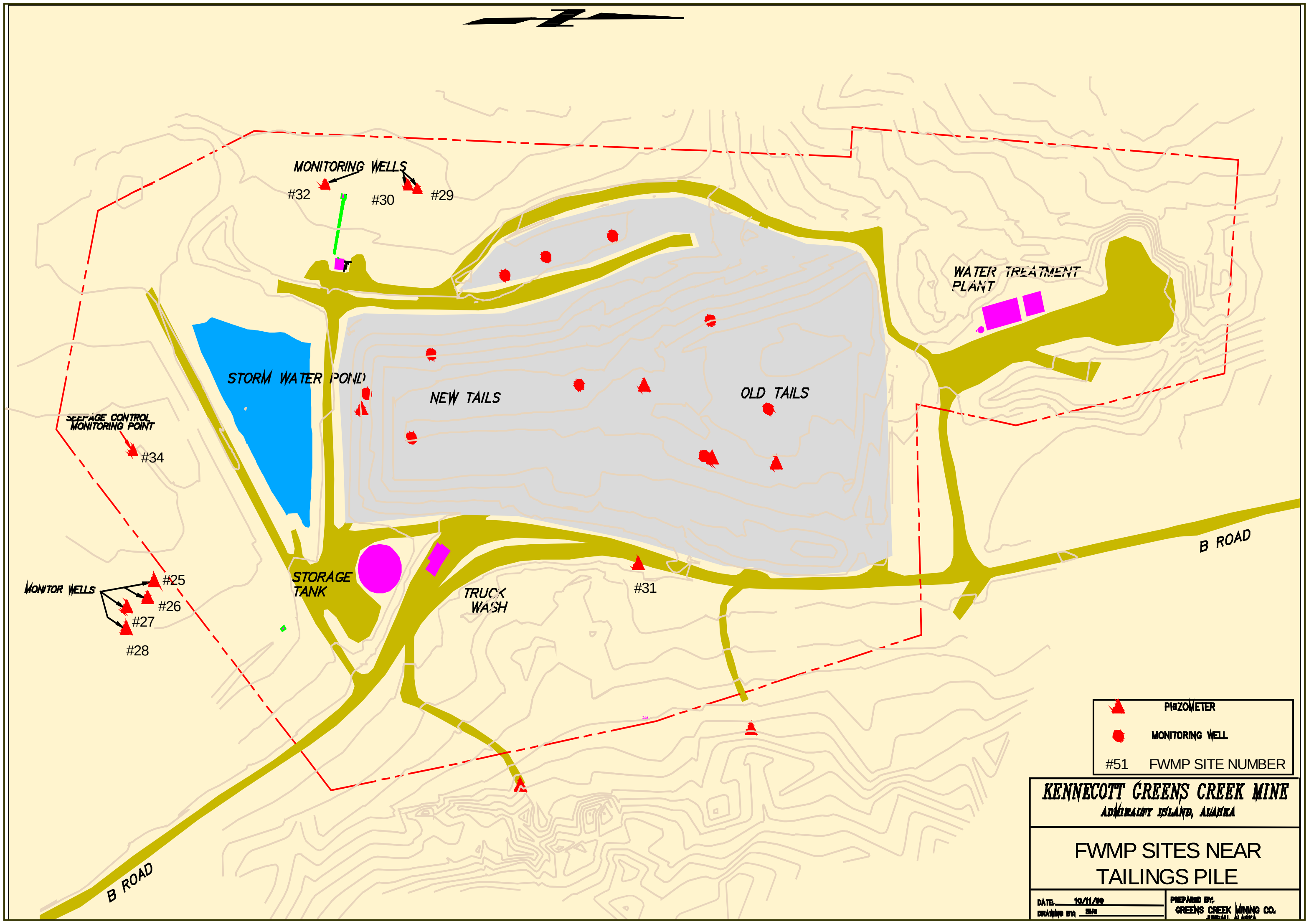

Figure 2. Layout of the Dry Tailings Facility at the Kennecott Greens Creek Mine
(Figure to be replaced by KGCMC as a replacement page)

1.3 Permits and Lease

1.3.1 U.S. Forest Service Lease

In September of 1988 the U.S. Forest Service issued lease number 4050-10 to Greens Creek Mining Company. This lease covers 39.89 acres for the purpose of constructing, operating and maintaining wastewater and tailings disposal systems for the Greens Creek Mine. Disposal of sewage sludge and residue from incinerated solid waste is approved within the tailings area consistent with State authorization and Forest Service approval of such plans.

1.3.2 Alaska Department of Environmental Conservation Solid Waste Permit

1.3.3 Army Corps of Engineers 404 Permit

In June of 1988 a permit for the construction of the tailings containment dams, on land leased by KGCMC from the Forest Service, was granted by the Army Corps permit #4-880269. The permit approved the placement of 75,000 cubic yards of material for construction of the main embankment and saddle embankment. The two dams would be used to contain the 3.5 acres of tailings impoundment waters. The tailings pile design criteria approval is for a maximum height of approximately 80 feet with a total design volume of approximately two million tons. Under the Corps permit, regular dam inspection schedules are to be maintained, with the Alaska Department of Natural Resources providing regulatory oversight. Dam inspections are further discussed in Section 3.

1.4 Site Characterization

The geochemical characteristics of tailings are an important factor that affects the design, monitoring and environmental performance of the dry tailings. The Greens Creek deposit is a high-grade sulfide-hosted poly-metallic mine. Silver, zinc, lead and gold are recovered from processed Greens Creek ores. Consequently, pyritic sulfur levels are elevated in the flotation tailings. Geochemical studies have been conducted throughout the life of the mine to better understand the nature of tailings material at Greens Creek, and relevant findings are reported in chronological sequence below.

1.4.1 Historic Geochemical Studies

The Environmental Assessment (1988) outlined the historical test work required to characterize the mill tailings and evaluate its potential to produce acid, and create an acid drainage. Two tests were developed, one a monthly pH check of the main finger drains, installed under the tailings pile, to determine pH changes inside the pile, and a formal leach test characterizing the acid-producing potential of the tailings.

The pH readings of the finger drains were taken on a monthly basis from July 1989 to January 1991 and are listed below. The finger drains were covered in February 1991 by the construction of additional pond capacity at the tailings facility. Prior to this date, the pH of the drains generally ranged from 6-7. Efforts to uncover the drains were successful in 1994 (see Figure 3, Section 1.4.2); however, flow resumption through the finger drains was re-directed to wet well #2. Presently, sampling of finger drain discharge is not possible. One of the wells developed during the 1994 surface drilling program may also be utilized for this purpose.

Static tests and kinetic leach tests of tailings were initiated in 1989 and continued for over 1 year. Results are contained in reports by BCRC (1990) and ASCI (1991). A series of laboratory static tests showed that the tailings had a potential to become acidic after weathering. Subsequent kinetic tests instead showed that the tailings had only a slight potential to form acid because of their slow reaction rate. The tailings sample had 12.1% pyritic S yielding an acid generating potential (AGP) of 379 t/1,000 t as $CaCO_3$. The sample had an acid neutralizing potential (ANP) of 244.8 for an overall Net Neutralization Potential (NNP) of –135 t/1,000 t as $CaCO_3$. Static test results such as these would normally be indicative of an acid generating sample. In addition to the kinetic tests that indicated little ARD risk, BC confirmation tests showed the sample to have an acid-generating risk estimated to be none to weak. A BC confirmation test consists of adding sulfuric acid to a sample to maintain the pH between 2.5 and 2.8 for 72 hours (BC AMD Task Force 1989). The sample is also inoculated with *Thiobacillus ferrooxidans*. After the initial 72 hours, additional fresh sample is added. If the pH is maintained below 3.5 because of the microbial oxidation of sulfides, the sample is assumed to have an inherent ARD risk. Both humidity cells and column tests showed an initial release of stored metals and acidity but solutions subsequently became neutral in pH and decreased in metals. These test results together indicated a low acid generating risk in the tailings. Dr. Adrian Smith (ASCI 1991) reviewed the tests results reported by BCRC (1990) and agreed with the conclusion that tailings would likely maintain an alkaline pH in the field and presented only a slight long-term potential for acid generation. The column and humidity cell tests indicated that elevated levels of zinc could be released, especially during the early stages of leaching when accumulated products of oxidation were mobilized (Figure 3, Section 1.4.2).

1.4.2 Recent Geochemical Studies

Geochemical testing of production rock, ore and tailings from the Greens Creek deposit in 1994 (KGCMC 1994) indicate that many of the materials have the potential to become acidic. However, owing to the abundance of calcium carbonate or dolomite in the samples (generally ranging from 10 to 60%), a very long period of weathering, estimated at more than 10 years in lab tests, would have to occur prior to development of acidic conditions. Before mining, the lag period was estimated to be more than 10.8 years. Work by Condon on production rock from Greens Creek (1999) suggests a lag period of similar duration. These estimates of lag period were based on modeling results of laboratory observations of pyrite oxidation. Actual oxidation rates are likely to be much less under field conditions due to passivation of reactive surfaces, reduced oxygen supply and lower temperature. Consequently, the average lag period (before generation of acidic pH levels in the majority of potentially acid generating rocks) is probably in the range of at least 20 to 50 years. The lag period will probably be longer in tailings than in production rock because of the accumulation of oxidation products in tailings and the diminished capacity for oxygen transport. It is also possible that oxidation reactions in either the production rock or tailings facility will slow to the point that acidification never occurs. The reclamation and closure methods being developed for the mine greatly increase this likelihood.

Even under the neutral pH conditions that are expected to prevail for tens of years in Greens Creek tailings, significant concentrations of soluble metals, especially zinc, may be released in a soluble form into water contacting the tailings. Consequently, water leaching through tailings may contain elevated zinc, and to a lesser degree other metals, such as cadmium, nickel and lead; and metalloids such as selenium and arsenic.

Static test (Figure 3) and paste pH results for 1999 grab samples (Figure 4) were consistent with the findings of the 1994 sampling effort. Tailings samples have an abundance of sulfide S (generally greater than 10%) but also have a high acid neutralizing capacity. The elevated ANP indicates that acidic conditions should not form during operation of the facility, allowing closure practices to provide long-term prevention of ARD. All measured paste pH values were above 6.5, and the majority ranged from 7.5 to 8.5. These data support the opinion developed during baseline studies that lag period would extend beyond the operating life of the mine.

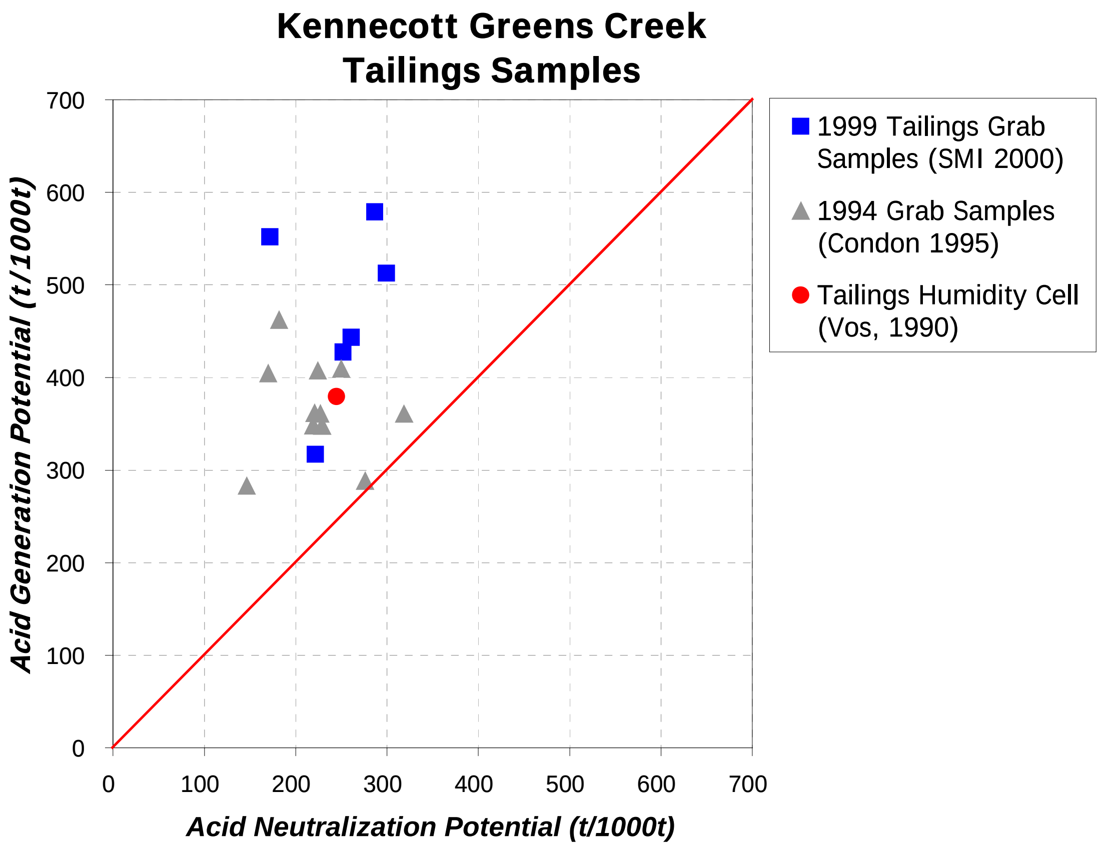

Figure 3. Net neutralization potential of various 1999 grab samples collected from the Greens Creek Mine facilities compared to analysis of 1994 grab samples from KGCMC 1995.

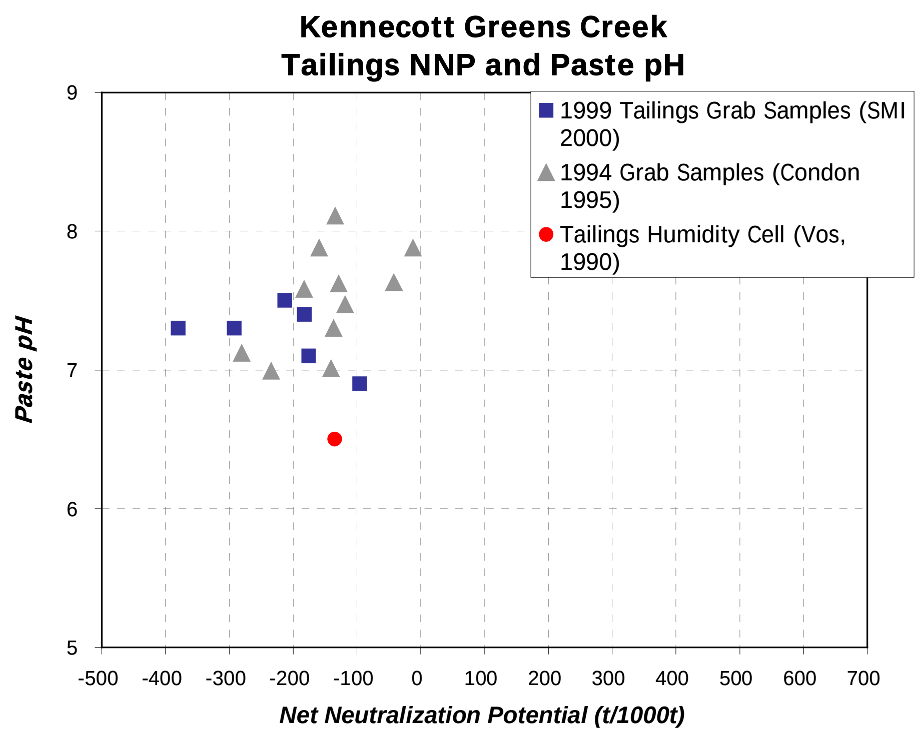

Figure 4. Paste pH and net neutralization potential of various 1999 grab samples collected from the Greens Creek Mine facilities.

The conclusion of the ARD and metal leaching evaluation by SMI (2000) was that there are three principal issues that affect ARD and metal leaching from the Greens Creek tailings facility including the siting and design of the individual facility, the operation of the facility, and reclamation and closure. Aspects of the facility design, operation and closure that serve to minimize ARD and metal leaching risk are described in this Appendix. Refer to the Reclamation Plan, Appendix 14 of the General Plan of Operations, for discussion of mine closure.

1.4.3 Seepage Issues

Prior disposal practices in the original tailings pile allowed development of saturated zones within the tailings pile. An HDPE liner was placed over portions of the tailings to reduce infiltration. Subsequently, water levels decreased within the pile. When the cover was removed from portions of the pile, water levels subsequently increased indicating that water levels are responding to vertical infiltration of meteoric water.

A detailed conceptual flow model was developed for the tailings site by others (EDE, 1997). The model incorporated generalized lithologies, including the tailings, underlying discontinuous peat, sand and till layers and bedrock. Included also in the model were the other hydrologic features such as natural drainages, and the various man-made features that form parts of the functional facility, (e.g. drains, ponds, and slurry walls).

The model was incorporated into a MODFLOW analysis to assess the system hydrology and allow prediction of various flows within, and discharges from, the system. Component hydrologic characteristics were derived from relatively extensive data obtained during site hydrogeologic investigation. The model was calibrated using measured or estimated flows at discrete locations and predictive modeling was completed for steady-state conditions for the ultimate facility configuration. Transport of seepage from the tailings pile away from the site after achieving steady-state was estimated at less than 1.5 gpm (EDE 1997 and 1999). Other modeling scenarios indicated that during operation, the tailings contained a higher water content than they will have after becoming fully drained after closure. The wetter condition could be attributed either to excess water (above residual saturation) contained in the tailings when placed, or due to infiltration into the tailings during or after placement. Vertical drainage of this excess water was unable to quickly drain out of the tailings mass, resulting in a build-up of hydrostatic head or a mound within the tailings. This mound was expected to dissipate in a few years after final closure. Thereafter, the groundwater system was not expected to remain in direct contact with the tailings system as it is now.

Water quality data were available on the chemistry of the east and west tailings drains from 1995 (Figure 5). Although the east drain was higher in zinc than the west drain, the water quality for each drain was consistent with the chemistry of contact water predicted in earlier studies by Vos (1990), having neutral pH and zinc in the range of 1 to 80 mg/L, with most samples near the lower end of this range. Pore water samples collected from the tailings in 1999 at a depth of about 4 feet also had neutral pH and somewhat lower zinc (2 to 3.5 mg/L) than measured in drains in 1995.

These data indicate that drains in the tailings facility collect a combination of groundwater underflow and water infiltrating through tailings. Additionally, the quality of water is consistent with the geochemical predictions developed during mine permitting, water is near-neutral and contains elevated levels of zinc and to a lesser degree other metals. These data indicate that oxidation is occurring in the tailings, and that carbonate dissolution maintains the pH near neutral.

1.4.4 Geotechnical Issues

Extensive in situ investigations of the tailings pile have been conducted since establishment of the pile (Klohn-Crippen, 1999). Work has included cone penetrometer testing (CPT) and standard penetration testing (SPT), in addition to test trenching, within the tailings and into the shallow foundation materials beneath the tailings.

Klohn Crippen completed stability analyses from this investigatory work to evaluate the current stability and projected long-term stability of the ultimate pile. The analyses employed shear strength parameters based on correlations using the information derived from the CPT and SPT work. Assessments included static and pseudostatic conditions, and liquefaction potential.

Seismic events considered included both the design basis and maximum credible events. Results of the static stability analysis found an adequate factor of safety with the tailings as-designed. The dynamic stability analysis indicated that there was a low but quantifiable risk of modest displacement of the tailings mass (up to 12 feet) with the occurrence of the design earthquake.

As a result of the evaluations, modifications in the tailings placement methods have improved the moisture and density characteristics in the new tailings pile. The modifications have optimized compaction and minimized development of saturated conditions in the active placement areas. Construction of the vehicle access causeway, and the cellular methodology employed, appear to be the key aspects of the plan that contribute to its success. Additionally, a west buttress was proposed and designed to stabilize the critical section of the pile. The construction of the west buttress in 1999 and 2000 will improve slope stability based on the analyses (Klohn-Crippen 1998). Water level monitoring within the pile should be continued to insure that seepage does not enter the pile through the more permeable rock placed in the causeway system, creating localized zones of saturation.

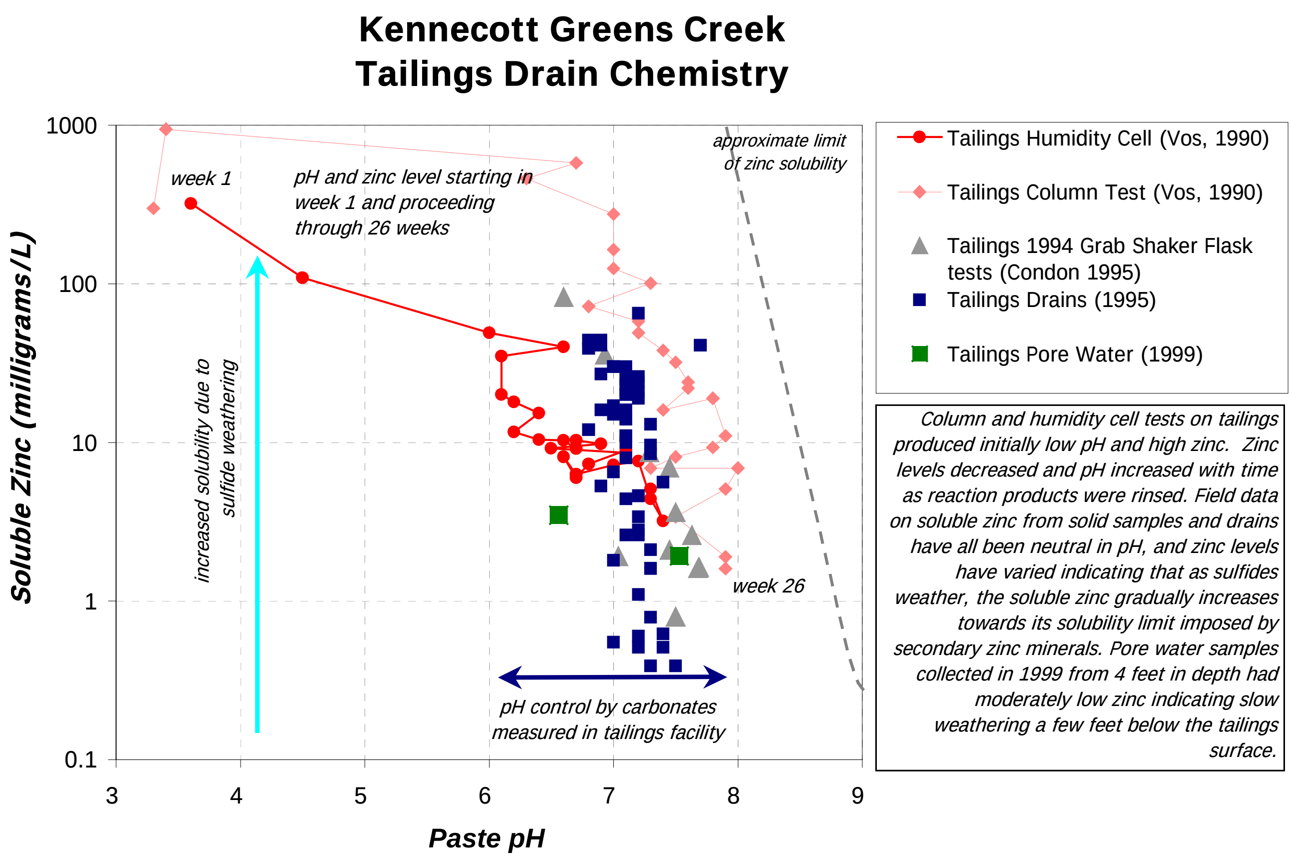

Figure 5. Chemistry of water in drains, seeps and pore water collected at Greens Creek in 1999.

1.4.5 Conceptual Model of Tailings

Following dewatering in the mill, tailings are placed in the permanent disposal facility in a manner similar to an aboveground landfill. Of the nominal 1,120 tons per day tailings production (Keith Marshall personal communication), approximately 50 percent of the tailings are used for underground backfill and the remainder are placed in the tailings facility. Design and operational management of the tailings facility is meant to keep the tailings in a moist but unsaturated state to prevent the development of seepage and to insure that the pile is geotechnically stable. Contact of the tailings mass with groundwater is minimized by the slurry wall installed upgradient of the facility and a network of finger and blanket drains installed beneath the tailings. Additionally, the fine texture, compaction, and unsaturated nature of the tailings also reduces ARD potential by minimizing flow and limiting diffusion of oxygen. This is to be achieved by compacting the tailings and grading the surface to promote runoff. At closure, a mine overburden cover that reduces infiltration of meteoric water and oxygen is to be placed over the facility then followed by revegetation to stabilize the site and to prevent long-term ARD by minimizing seepage and oxidation processes.

2.0 TAILINGS FACILITY OPERATION

2.1 Tailings Dam Structure

2.1.1 Introduction

The purpose of this section is to identify specific operations and maintenance requirements for the safe operation of the tailings impoundment. Procedures for tailings disposal are included in Section 2.1.4, Tailings Pile Operation and Maintenance.

This section meets the requirement for a low hazard Class D structure. The dam classification is contained in the U.S. Forest Service Special Use Lease 4050-10 approved September 1, 1988. The section also complies with ADNR Certificate of Approval for Dam Safety No. 88-4 approved May 6, 1988; and Certificate No. 89-7.

2.1.2 Operations

The impoundment is operated to receive overflow from Tank 6 that will generally be comprised of wastewater from the mill site, the Hawk Inlet facilities and the dry tailings placement area. Waste water flow is regulated at the 920 pump station which transports mine discharge, 920 site runoff (collected at Pond A), Site 23 runoff, and treated mill process effluent through an eight mile HDPE pipeline to the tailings impoundment. In addition to tailings solids from ore processing, the tailings facility is permitted for placement of non-hazardous wastes from the site including sediments removed from de-gritting basins and settling ponds, dewatered sewage sludge, sediment from the wastewater treatment plant, incinerator ash and residue from combustion of wood waste and camp wastes

The purpose of the tailings structure is threefold:

- Collection of waste water prior to treatment and subsequent seawater discharge under the NPDES permit, (Appendix 2);
- Receipt and placement of dry tailings; and

- Capture and treatment of dry tailings runoff prior to seawater discharge under the NPDES permit.

The Greens Creek Concentrator generates approximately 1,120 tons of filter-pressed tailings a day. Approximately 50 percent are mixed with cement and trucked underground for placement in the backfilling process. The remainder of the tailings (approximately 50 percent) are trucked to the tailings impoundment area for disposal. Tailings being transported are dewatered to approximately 15% moisture content by dry weight (Klohn-Crippen, 1999), which is slightly below the optimum moisture content. Regular precipitation events thus increase the moisture content of these materials roughly equal to the optimum compaction moisture content.

2.1.3 Loading and Hauling

The tailings are loaded at the concentrator loadout area into trucks dedicated to handling tailings utilizing a front-end loader. The tailings loading area is cement-floored. Tailings may spread from the cement-floored tailings storage area to the loading area during loading. Runoff from the cement-floored tailings storage and loading areas drains to Pond A, from which it is pumped to the tailings water treatment facility. Runoff from the tailings loading area is not permitted to drain directly into Greens Creek or any other water body. When loading tailings, operators' exercise care to minimize tailings spillage reducing tailings accumulation in the gravel area and potential runoff.

Two truck options are available to haul tailings. The first option is to transport the mill tailings in 45-ton capacity covered maxhaul trailers. These units comply with the U-80 design loading specified for the bridges on the road. Each truck will be inspected prior to transporting to assure the tailgate is locked to prevent spillage, the rubber seal around the tailgate is in good condition, and trailer covers are in place and in good working order. All conditions must be in proper working order or the trailer will not be used.

Truck loading to 45 tons requires 10 to 12 round trips per day. The road surface is required to be kept in good driveable condition for either option. Snow removal, ice removal and dust control are necessary functions performed (see Road Operation and Maintenance Plan, Appendix 8) on a seasonal basis. Freeze/thaw cycles may necessitate sanding the road surface in addition to chains being applied to both drive wheels on the tractors and the trailers for icing conditions. During thaw periods, it may be necessary to restrict operations temporarily, or reduce payload to prevent road degradation. Dust control will be performed as necessary. A water truck will be utilized to keep dust generated by truck movement to an acceptable level. If tailings are spilled along the roadway, they will be immediately recovered and placed in the tailings facility.

If operations are curtailed (i.e., transporting tailings), the tailings will be stored at the load-out site. The load out site is covered and has a storage capacity for approximately 24 hours of production. If that time limit is exceeded, moving tailings underground will receive priority until the road can accommodate normal traffic, or the tailings impoundment can accept additional tailings material.

2.1.4 Tailings Pile Operations and Maintenance

A french drain is established on the west side of the pile in a downgradient direction. It captures and accumulates leachate from the tailings. There is a pump with a float switch that automatically discharges into Pond 6. This system is visually inspected every working day. Leachate samples are taken monthly in order to characterize water quality.

Daily obeservations are made by personnel working in the tailings area (Form A-2). Observation by operator ensures the tailings perimeter is safe for tailings placement and/or spreading. The shift supervisor is contacted prior to tailings placement if abnormal conditions are noted. During severe conditions, tailings placement will stop until suitable conditions occur.

The thickness of the initial tailings lift placed in the dry tailings facility measured as much as 5 feet in order to support equipment traffic over the muskeg foundation conditions existing on the site. The approach used to place tailings was modified in 1996 for resumption of operations. These procedures were further adjusted in 1999 as a result of the review by Klohn-Crippen (1999). Recommendations of Klohn-Crippen adopted by KGCMC follow.

A revised placement method was developed. The method involved placing the tailings in a cellular format. In this method tailings are placed in discreet cells, which allows better control over compaction, drainage control and pore pressure dissipation. The key to the success of this method is the management of the surface water, especially during the periods of high rainfall. A summary follows:

An access road is constructed down the center of the tailings pile and the pile is divided into a number of cells. Prior to placing the tailings, any saturated tailings on the placement surface are cleaned off. The tailings are placed in one cell at a time. The tailings are spread into a sloped one-foot lift and immediately compacted by several passes with a bulldozer followed by two to three overlapping passes of the vibratory roller. If the delivered tailings cannot be placed and compacted upon arrival at the tailings pile, the tailings are stockpiled to minimize any additional moisture absorption (or drying during warm periods) to occur. This will help ensure that the tailings remain at the optimum moisture content prior to placement and compaction. During placement, the top surface of the cells are graded away from the central road, to allow any surface water to run off, and sealed as best as possible to minimize ruts or indentations, so that infiltration into the placed tailings is minimized. Due to the limited placement area, lifts can be adjusted to maximize cell placement and slope consistency. Placement then progresses to another cell. This allows for any construction pore pressures that build up in the originally placed tailings to dissipate.

Crossroad construction is dictated by tailings compaction. Successful compaction will support haul truck traffic making it practical to remove some or all of the planned crossroads from the design unless excess moisture is present.

The tailing area will be graded in active areas to allow adequate drainage. Adequate benchmarks and other surveying data will assist in establishing proper grade.

2.1.5 Concurrent Reclamation

The dry tailings facility is built in thin lifts and will attain a maximum thickness of 80 feet under the current permit. Consequently, the opportunity to concurrently reclaim portions of the facility is limited to completed sideslope areas where the toe of the tailings have reached the permit limit, and where access is no longer required. Where possible, concurrent reclamation will be practiced on completed slopes. For concurrent reclamation purposes, KGCMC shall construct and test the performance of one or more engineered covers on the Production Rock piles or tailings facility. Once an engineered cover has been selected, then KGCMC shall complete a water balance and mass load model, as described in Section 4.1.4, that will predict the environmental performance of the reclaimed facility. After acceptance of this evaluation by regulatory Agencies (USFS and ADEC), then KGCMC will be able initiate concurrent reclamation activities. The area of disturbed and reclaimed acreage within the facility shall be reported to the USFS in their annual report.

2.1.6 Final Reclamation

Waste rock from the mine will be utilized to cap the mine tailings. Waste rock used for final cover of the tailings have an NNP value of greater than 0t/1,000t. After the waste rock is placed, placement of an engineered cover and revegetation will begin (see GPO Appendix 14). Final grade of the dry tailings pile will be 3H:1V except at the north face where slopes of 2H:1V are allowable because of a waste rock ramp to the top of the tailings pile that is raised simultaneously with the adjacent tailings.

2.2 West Buttress

The West Buttress (Klohn-Crippen 1998), a mass of drained and compacted tailings with a 3H:1V downstream slope, has been developed to address seismic stability concerns identified in section 1.3.4. The West Buttress was constructed west of the Old Tailings area and east of the slurry wall in the Perimeter Dyke. The key components of the West Buttress development were:

- Extension of the existing French Drain to the north.
- Relocation of the surface water interception ditch on the existing pile.
- Installation of a temporary wet well at the south end of the French Drain.
- Removal of peat and loose gravelly sand to expose till or bedrock foundation materials.

- Placement of drainage blanket and finger drains.
- Installation of filter cloth over drains.
- Relocation of services.

Tailings are placed in the West Buttress in the same manner as in the Active Tailings Pile. Details on the construction of the West Buttress are contained in Klohn-Crippen (1998).

2.3 East Expansion

Construction of the East Expansion Area, described by Klohn-Crippen (1999b), was initiated in 2000. Maximum slopes on the outside perimeter of the East Expansion will not exceed 3H:1V. The components of the East Expansion include:

- Construct surface water diversions to collect and divert non-contact water around the facility.
- Place a slurry wall interception and collection system to divert non-contact groundwater around the facility.
- Create a collection system to convey contact water to the water treatment plant.
- Develop a drain system to prevent contact with groundwater, maintain low phreatic levels and to collect seepage.
- Relocate a short stretch of the B-Road and all utilities.

Tailings will be placed in the East Expansion in the same manner as in the Active Tailings Pile. Details on the construction of the East Expansion are contained in Klohn-Crippen (1998).

3.0 INSPECTIONS AND MONITORING

3.1 Routine Inspection

The following observations and visual inspections are required by the U.S. Forest Service lease, the Alaska Department of Environmental Conservation who administers the solid waste program, and the ADNR Dam Safety Certificate, and are an integral part of the overall operations and maintenance of the tailings impoundment. Additional construction quality assurance and water quality monitoring requirements are described in more detail in subsequent sections.

USFS

- Inspection by a qualified engineer every two years for the life of the structure;
- Inspections following earthquakes, major storms, or over flow (other than spillway); and
- 1991 inspection and then every two years.

ADEC

- Daily recording of the volumes and types of waste placed in the facility;
- Monthly inspection of seepage from the pile and of leachate collection and surface water diversion systems.

ADNR (Note this section to be amended by KGCMC, a replacement page will be forwarded.)

- During first 30 days of operation - daily inspection.
- After first 30 days of operation - weekly inspection.
- 30 days after reaching normal level - qualified engineer approval in advance by ADNR.
- After initial inspection - every five years.

Daily, weekly, and special inspections will be used to check for cracks, bulging, and settling. These or other abnormal conditions may trigger additional technical safety inspection(s) or initiate the development of alternative inspection protocols.

Inspections will be recorded on the attached form (see Attachment A-1 and A-2 of this Appendix) derived from the ADNR Division of Land and Water Management, Visual Inspection Checklist, Alaska Dam Safety Program. Records of visual inspections will be kept in the Greens Creek Environmental Department files. Certified Engineer inspections will also be kept on file and a copy submitted to the USFS and ADNR.

3.1.1 Solid Waste Inspections

The Alaska Department of Environmental Conservation Solid Waste Permit #8712-BA014 states:

> "The permittee shall ensure that at least one person who is familiar with the requirements of this permit and with the applicable requirements of the state solid waste management regulation (18 AAC 60), conducts a visual inspection of the facility at least once per year. Any violations found during those inspections shall be reported to the permittee, and appropriate corrective action taken."

All records of visual monitoring inspections and corrective actions taken are maintained by the KGCMC Environmental Department, and are available on request. Refer to Appendix 7 of General Plan of Operations for the solid waste permit conditions and stipulations.

3.1.2 Tails Pile Inspections

Daily inspections are conducted by tailings pile operators as previously stated in this section. Records of abnormal conditions are maintained on employee time cards. As-built drawings of the tailings basin, which show standardized cross-sections, will be provided annually to the Forest Service.

3.2 Compaction Testing

Klohn-Crippen (1999) developed the following testing program for the dry tailings.

A minimum of six (6) readings from the nuclear densitometer is required for each test site. Due to the fine-grained nature of the tailings, the nuclear densitometer cannot correctly measure water content. Consequently, if an incorrect water content value is used, then dry density of the tailings will also be calculated incorrectly at that location. To correct this, the measured water content of tailings samples were compared to the densitometer readings to derive a correction factor. This corrected water content is then used in conjunction with the wet density from the nuclear densitometer, to determine the correct dry density of the tailings.

The level of compaction achieved is based on the ratio of measured to maximum dry density. To determine this ratio, the calculated dry density is compared to the maximum achievable dry density, commonly known as the standard Proctor maximum dry density. Prior to a 1999 Klohn-Crippen site, visit an average standard Proctor value of 132 pounds per cubic foot (pcf) was used to compare against the measured dry densities, even though standard Proctor values ranged from 123 pcf to 136 pcf for the tailings. To ascertain the correct standard Proctor value for the tailings at a particular site, samples were taken and a series of one point standard Proctor test were completed in the KGCMC laboratory. This one point value was used in conjunction with the family of standard Proctor curves, obtained from testing of many samples of the tailings, to determine what value best represents the standard Proctor for the material. Subsequently, standard Proctor tests are completed on tailings samples at regular intervals to form a larger database of curves.

Records to be collected and retained by KGCMC staff include:

- Standard count sheet for the nuclear densitometer to track any problems occurring with the unit;
- Field placement and density summary sheets to track location and density of tailings in the facility;
- Weather data to help achieve a better understanding of tailings placement performance, as related to compaction; and

- A summary report which summarizes the location of placed tailings, volume of placed tailings, test results, and any discussion of incidents related to the tailings facility. The summary report is submitted periodically to a qualified geotechnical engineer for review and comments.

3.2.1 Tailings Facility Maintenance

If problems are noted during any inspection, KGCMC will have a qualified engineer inspect the component of the system that fails to meet operating standards, and provide recommendations for correction.

3.2.2 Reporting Schedule

All monitoring data described in chapter 3 and 4 of this appendix will be submitted to the USFS and ADEC in Annual Reports. Each report will contain results for the prior calendar year and will be submitted by March 31, unless an extension is granted by the Agencies. Monitoring records will be maintained at the site in a fashion that allows on-site inspection.

3.3 Emergency Action Plan

The following actions will be taken in the event of an emergency:

- Unsafe conditions/impending failure - stop water inflow from all managed sources.
- Notification of Forest Service Personnel, Monument Manager 586-8970.
- Notification of the State of Alaska ADNR Dam Safety Officer (Charlie Cobb) at (907) 269-8636
- Persons to be notified downstream - not applicable.
- Map delineating area of inundation.
- Person responsible for carrying out this Plan is the Environmental Manager, phone (907) 586-7089.

4.0 TAILINGS INTERNAL ENVIRONMENTAL MONITORING PROGRAM (TIEMP)

4.1 Purpose

The Freshwater Monitoring Plan (GPO Appendix 1) was established to monitor the environmental performance of the Greens Creek facilities as well as other disturbed areas during operation. Monitoring sites have been established to periodically measure surface and groundwater quality outside the perimeter of the tailings facility. Measurement and evaluation of hydrologic and geochemical processes that occur within the tailings facility is conducive to better understanding the behavior of the tailings and their potential interaction with the environment. Consequently, a Tailings Internal Environmental Monitoring Program (TIEMP) will be conducted for this purpose. It is important to remember that water quality data collected as part of the internal monitoring program represent “mine water”, or “contact water” that is contained, collected and treated prior to discharge under the KGCMC NPDES permit. As a result, data are not to be compared to compliance levels established for ambient surface and groundwater peripheral to the site. However, measurement of the changes in the quality and volume of seepage over time during operation and after capping will aid in evaluating the need for long-term treatment. Additionally the data will help in the design of post-closure water management and treatment systems, should these be required.

Hydrologic and geochemical processes are important factors that define the success of the management of the tailings facility. Operational techniques and closure approaches were designed to prevent acidification, minimize infiltration of oxygen and water, and to reduce metal loading from the facility. Short-term control of metal loading relies on minimizing ARD and metal release and on the collection and treatment of contact water. Long-term control measures will emphasize the minimization of acidification, oxidation, and infiltration of meteoric water. As a result, the TIEMP will provide information about the following:

- geochemical behavior of tailings and production rock placed in the tailings facility; and

- collection of data that will allow development of a mass load model for the tailings that describes the movement of meteoric water through the pile, and the chemistry of pore fluids contained in the tailings.

4.1.1 Geochemistry of Tailings and Production Rock

The net neutralization potential (NNP) and the paste pH of materials within the tailings facility will be measured on samples that are collected from representative locations within the facility. The sampling and testing requirements are outlined below.

Each calendar year that the mine is active, a minimum of 16 samples of fresh tailings will be collected for analysis of NNP. Samples should be collected from a recent placement cell and should consist of a composite sample taken from the top 6-inch depth. At least 4 samples will be collected each quarter. The date collected and the approximate location within the pile will be recorded for each sample. Static tests will be determined using the modified Sobek Method used for analysis of prior samples (1994 and 1999 grab samples). The NNP will be calculated on the basis of the Sobek acid neutralization potential in tons per 1,000 tons as calcium carbonate minus the non-sulfate sulfur (pyritic sulfur found by summing the nitric acid extractable and the residual S fraction) times 31.25. Alternatively, if barite is found to comprise the majority of the residual sulfur, then the pyritic sulfur will be assumed to equal the nitric fraction only.

Each calendar year until final closure of the tailings, a minimum of 20 samples but not less than 1 sample per 2 acres covered by tailings, will be collected for analysis of paste pH. Samples should be aerially distributed across the facility with samples collected from portions of the facility that vary in age. The samples should be collected as composites from the top 6-inch depth. The cell designation of each sample will be recorded. One of every 5 paste pH samples will be randomly selected to be analyzed for NNP value. Additionally, each sample with a paste pH of less than 6 will also be analyzed for NNP values.

All results will be provided in an annual monitoring report submitted to the USFS, and ADEC. Data will be graphed in a manner similar to Figure 3 and Figure 4. If a significant reduction in average NNP value is observed (of more than 50 t/1,000 t), if the acid neutralization potential

(ANP) of more than 25% of the samples is below 50 tons/1,000 tons, or if more than 10% of the paste pH values are below 5, then an expert in ARD will be asked to review the information, and if necessary, to develop a suitable management plan. Additionally, the USFS and the ADEC will be informed of the results and the management plan will be submitted for their review and approval prior to its implementation.

4.1.2 Pore Water Chemistry

Management of Contact Water

Water that contacts tailings is collected and treated during operation of the tailings facility. After closure, surface water will no longer contact tailings as occurs now. Consequently, only interstitial water within the pile will contact tailings. After closure, the "draindown" of water from the dry tailings stack, if any, and the long-term net infiltration through the engineered cover will determine the quantity of contact water that may exit the site. The chemistry of contact water is therefore important in determining long-term mass loads of metals that may be released.

The chemistry of contact water will be sampled in three ways: surface water, groundwater beneath the facility and interstitial water.

Surface water and groundwater that may have contacted tailings will be collected from the internal stations, identified in the subsequent section. Additionally, interstitial water will be collected using suction lysimeters installed at nested depths at representative locations in the tailings facility. In order to avoid interference to placement and compaction of fresh tailings solids, lysimeter nests will be located in inactive areas of the pile. The schedule for installation of lysimeters is described in the subsequent section.

Data Quality Objectives

Data quality objectives (DQO's) define the amount, kind, and quality of data that are required to make relevant decisions. In the context of the TIEMP, data on the chemistry, and, if applicable, flow rate of contact water are required to develop a mass balance model. Additionally, water chemistry data will be used to identify significant trends in the chemistry of contact water. Such trends could reflect changes in the geochemical nature of the tailings by processes such as acidification.

The DQO's developed for the contact water include a constituent list, recommended analytical minimum levels for trace constituents, monitoring frequency, and quantitative limits for precision and accuracy of laboratory data and completeness.

Constituents to be analyzed consist of a series of "indicator parameters" (Table 1). Based on review of existing data from KGCMC collected through the Freshwater Monitoring Plan, some or all of these constituents will always be found in contact waters, Therefore, changes in their concentrations will identify changes in the amount or chemical nature of contact water that is detected at a monitoring station. In addition to the indicator parameters (suite H from the FWMP), common ions will also be analyzed.

The analytical minimum level is defined as the concentration of a constituent at which it can be reliably quantified according to the precision and accuracy DQO's. Generally, the minimum level occurs at a concentration that is 3.18 times higher than the minimum detection level reported for the method of analysis. The minimum levels for use in the TIEMP are identified for trace constituents in Table 2. The method minimum level is developed based on low concentrations of the analyte added to reagent grade water. In contact waters, the matrix-specific ML may be higher than the value in Table 2 due to matrix interference. Such data quality issues will be considered when developing QA/QC reports for the data collected in the TIEMP.

Table 1. Analyte Suites

Suite H		
Conductivity	Dissolved Arsenic	Dissolved Mercury
pH, Temperature[1] & Hardness	Dissolved Cadmium	Dissolved Zinc
Sulfate	Dissolved Copper	
Total Alkalinity	Dissolved Lead	
Common ions		
Dissolved Calcium	Dissolved Magnesium	Dissolved Sodium
Dissolved Potassium	Nitrate plus nitrite	Bicarbonate
Silica	Chloride	

Samples will be collected from each station monthly for surface water stations and quarterly for groundwater stations and lysimeters.

Precision is a measure of the ability to replicate an analysis and is expressed as the relative percent difference (RPD). The RPD criterion for water samples is ±20% and is only applicable when the analyte concentration is more than 5 times the MDL, and as long as the native amount is not greater than 4 times the spiked amount.

Accuracy is a measure of how close the analytical result is to the true concentration of the analyte, and is expressed as percent recovery (%R). The Matrix Spike/Matrix Spike Duplicate (MS/MSD) criteria are 75-125 %R for all metals. The criteria are only applicable for analyses as long as the native amount is not greater than 4 times the spiked amount. The accuracy limits for the Laboratory Control Sample (LCS) are method dependent.

Completeness is a measure of how many planned analyses for all analytes actually resulted in usable data, defined as all data that is not rejected, and is expressed in percent (%). The completeness criterion is 95% for a water year, which is October 1st through September 30th. Samples that cannot be collected due to restricted winter access or to low flow are not counted as planned samples in the determination of completeness.

Table 2. Recommended Minimum Levels for Trace Constituents

ANALYTE	AWQS[1]	MDL[3]	ML[4]
Arsenic, T, µg/l	50 l	50	160
Cadmium, TR, µg/l	0.52, 0.38	1.0	3.2
Copper, TR, µg/l	5.1, 3.6	10	31
Lead, TR, µg/l	0.90, 0.54	2	6.4
Mercury, TR, µg/l	0.012	0.2	0.64
Silver, TR, µg/l	0.73,0.37[2]	5	16
Sulfate, mg/l	250	50	160
Zinc, TR, µg/l	45.6, 32.7	10	32

T = measured and reported as total, TR = measured and reported as total recoverable

1. *If AWQS is hardness dependent, two numbers are listed for the purposes of calculating the ML and MDL. First number listed is based on a hardness value of 37 to represent the 25th percentile of surface water hardness values, the second number listed is based on a hardness value of 25 to represent the 25th percentile of groundwater hardness values. AWQS is for chronic conditions unless otherwise noted. The actual hardness dependent AWQS for that constituent will depend on the actual hardness of the sample, not on the number that appears in this table.*

2. *AWQS is a 24 hour average (acute).*

3. *MDL is the minimum detection level for laboratory analysis. The value selected will allow detection of significant changes in the chemistry of contact water.*

4. *ML based on MDL times 3.18, rounded to not more than 2 significant digits.*

Samples from surface water stations will be collected monthly while quarterly samples of groundwater/interstitial waters will be obtained. Samples will be analyzed for the constituents in Table 2. All analyses will be in a dissolved form. The sample collection protocols and the analytical detection levels specified in the Freshwater Monitoring Plan for downgradient monitor wells will be used for analyses of these samples. Sampling sites will include all listed in Table 3.

All water quality data collected will be transmitted in annual reports to the USFS and ADEC. There are no specific compliance levels for these data, but information should be presented on graphs of concentration vs. time to graphically illustrate trends in the data, if any.

Table 3. Internal Sampling Locations

Station	Measurements	Frequency	Comments
B-2 Well	water level and chemistry	quarterly	Located in old tailings area
New borehole to be sited by KGCMC	water level and chemistry	quarterly	Located in active tailings, location subject to Agency approval
Wet well 2	flow and chemistry	monthly	
Wet well 3	flow and chemistry	monthly	
Lysimeter nest 1 (consists of 4 lysimeters at 2 feet, 4 feet, mid pile, pile base)	chemistry	quarterly	Constructed in 2001, sampled if suction is maintained
Lysimeter nest 2 (consists of 4 lysimeters at 2 feet, 4 feet, mid pile, pile base)	chemistry	quarterly	Constructed in 2004, sampled if suction is maintained
Lysimeter nest 3 (consists of 4 lysimeters at 2 feet, 4 feet, mid pile, pile base)	chemistry	quarterly	Constructed in 2007, sampled if suction is maintained

Schedule for Station Installation

An existing or new borehole within the active tailings area will be proposed by KGCMC for use in the TIEMP. The location and design of the borehole is subject to Agency approval. The new borehole should be ready for sampling by the third quarter of 2001. Additionally, one nest of 4 lysimeters will be established in 2001, with samplers at 2 feet, 4 feet, mid pile, and in the basal 5 feet of the pile. An additional nest of lysimeters will be installed in 2004 and in 2007 in recently completed portions of the pile. Samples will be collected twice per year and will be analyzed for the same dissolved constituents listed above and using the same analytical detection levels.

All water quality data collected will be included in annual reports to the USFS, ADEC, and ADNR. There are no compliance levels for these data, but information should be presented on graphs of concentration vs. time to graphically illustrate trends in the data, if any.

4.1.3 Water Flux and Cover Performance

As yet, no significant area of tailings has been constructed to final grade. Consequently, engineered covers have not yet been placed over any portion of the tailings. When cover is initially placed on the tailings, a monitoring plan that measures the performance of the cover shall be undertaken within 1 year of cover deployment. At a minimum, the monitoring plan should allow calculation of the flux of meteoric water and oxygen through the base of the cover into the tailings. The monitoring plan will be submitted to the USFS, and ADEC, for review and approval prior to its implementation.

4.1.4 Development and Calibration of a Water Balance/Mass Load Model

After a minimum of 2 years of cover performance monitoring data has been collected, a water balance and mass load model, applicable to post-closure conditions should be developed. The model report should describe the conceptual hydrogeochemical model that includes groundwater flow paths for the hydrologic basin within which the tailings are situated. Also, the mass flux of water and metals out of the reclaimed tailings, the fate of constituents along the flow path, and the resultant seasonal concentration of critical constituents in receiving water should be predicted. The results of the mass load model will be submitted to the USFS, ADEC, and ADNR.

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KENNECOTT GREENS CREEK MINING COMPANY

GENERAL PLAN OF OPERATIONS

APPENDIX 14

RECLAMATION PLAN

Date:
October 2000

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1. Introduction

1.1. Purpose and Scope of Reclamation Plan

The Kennecott Greens Creek Mining Company (KGCMC) reclamation plan is designed to return the mine to a near-natural condition as contemplated in the Final Environmental Impact Statement (FEIS). Additionally, the goal of this plan is to implement concurrent reclamation, as appropriate, to minimize the effects of disturbance while mining within Admiralty National Monument (Monument). Also, the reclamation plan is designed to meet the Forest Service Manual's definition of reclamation: "Those actions performed during or after mineral activities to shape, stabilize, revegetate, or otherwise treat the affected lands in order to achieve a safe and ecologically stable condition and land use that is consistent with long-term forest land and resource management plans and local environmental conditions." Additionally, the reclamation plan is designed to fulfill the requirements of the State of Alaska for facilities over which they have jurisdiction through the Alaska Department of Environmental Conservation (ADEC) including the Solid Waste Management Program and other regulatory initiatives, and the Reclamation Act administered by the Alaska Department of Natural Resources (ADNR). Finally, the plan addresses the requirements of the US Army Corps of Engineers (COE) and the City and Borough of Juneau (CBJ).

This reclamation plan sets performance goals applicable to interim, concurrent and final reclamation, and addresses post-closure monitoring requirements. It also sets scheduling and other standards for reclamation and for final closure planning requirements, and it explains how detailed, regularly-updated reclamation task planning will be used for purposes of calculating a reclamation bond.

1.2. Site History

Kennecott Greens Creek Mining Company (KGCMC) began operating a mine/mill complex in the upper Greens Creek drainage of northern Admiralty Island in February 1989. The production startup was the culmination of approximately two years of intense development and construction following a 10-year permitting effort. In 1993 the mine suspended operations primarily because of low metal prices. Operations restarted in 1996 following extensive feasibility studies, recovered metal prices, and site-wide reconstruction efforts. The facility design as it is currently permitted and operated is shown in Figure 1.

Kennecott Minerals

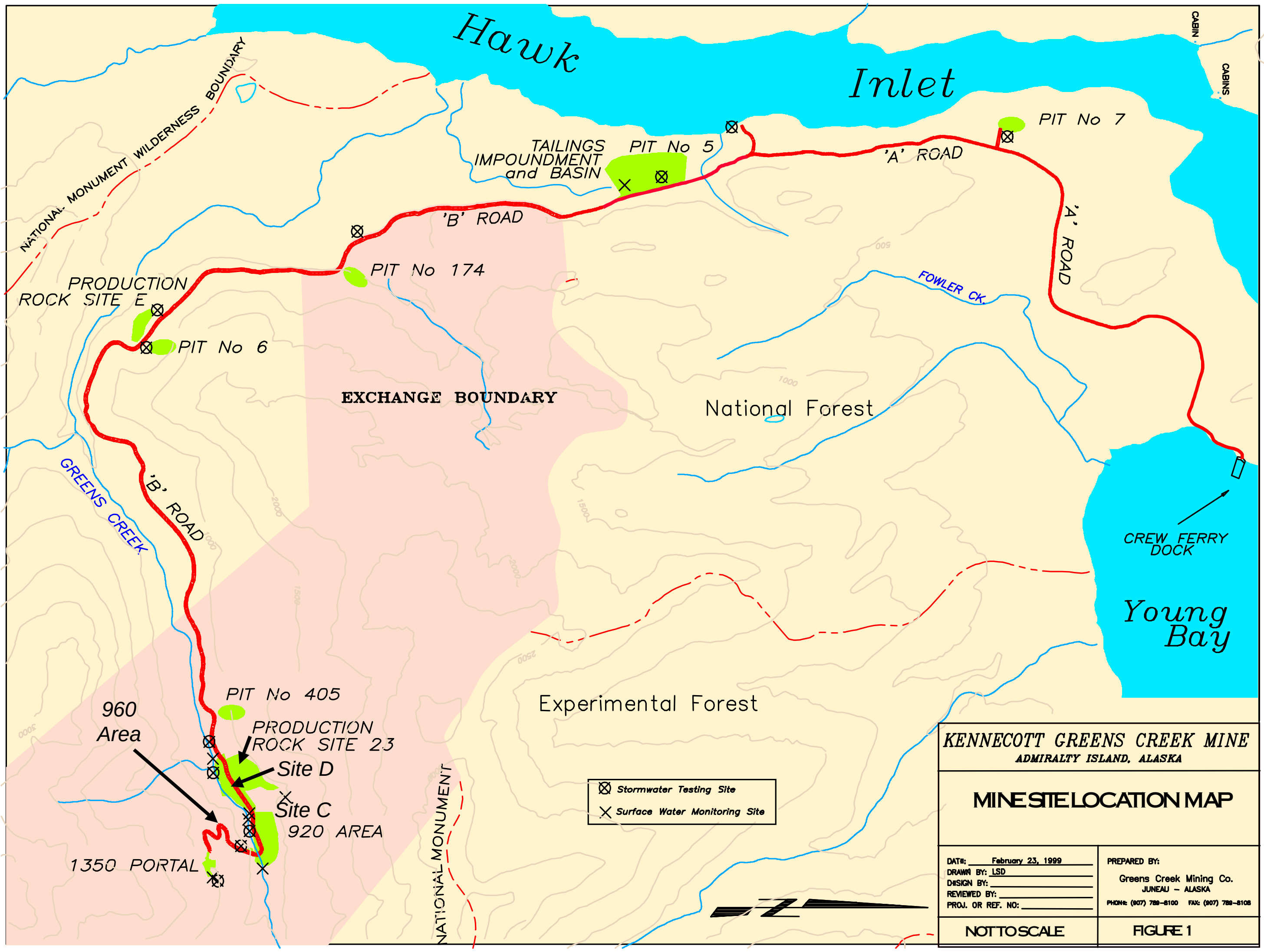


Figure 1. Layout of the Greens Creek Mine.

1.3. Post-Mining Land Use and Ownership

The land comprising the Greens Creek mine, inclusive of all Admiralty Island facilities, consists of both publicly and privately owned uplands and tidelands. Greens Creek leases parcels from the United States on both the Monument and non-monument lands. It uses other public lands pursuant to special use permits issued by the Forest Service and leases issued by the State of Alaska. It owns land on Admiralty Island both as a result of patenting mining and millsite claims and through transfer of private lands in the historic cannery area from its predecessor. Additionally, Greens Creek holds subsurface and restricted surface use rights to approximately 7,300 acres of public lands as a result of a land exchange made pursuant to the Greens Creek Land Exchange Act of 1995 (Pub. L. 104-123 April 1, 1996).

Under the land exchange agreement, certain of the private lands (e.g. patented claims) owned by Greens Creek ultimately will be transferred to the United States and the 7,300 acres of subsurface and restricted-use surface lands patented to Greens Creek in 1999 will revert to the United States. The land exchange agreement does not impose special reclamation requirements on these lands. It requires simply that they must be reclaimed in accordance with applicable laws and the approved reclamation plan.

Final reclamation of the mine facilities will take into account anticipated post-mining land uses. Since such uses likely will be limited primarily to monument-related activities, returning the surface to a near-natural condition should satisfy post-mining land use needs as to most of the lands. Private lands that will retain their private status, if any, after mining were developed for non-monument uses prior to creation of the Admiralty Island National Monument. After closure, Greens Creek will consult with the ultimate landowner, as well as any agencies having regulatory authority over reclamation of such lands, to determine the final disposition of structures and facilities then having remaining useful life.

1.4. Agency Requirements

1.4.1. United States Forest Service

The Forest Service has numerous reclamation requirements for the Greens Creek mine. These requirements can be categorized as general Forest Service mining rules, Forest and Monument specific rules, and decisions reached through the NEPA process. These are discussed in Table 1.1 through 1.4, respectively.

Table 1-1. General Forest Service reclamation requirements.

General Forest Service Mine Reclamation Requirements

CODE OF FEDERAL REGULATIONS
TITLE 36--PARKS, FORESTS, AND PUBLIC PROPERTY
PART 228--MINERALS

Subpart A--Locatable Minerals

Sec. 228.8 …All operations shall be conducted so as, where feasible, to minimize adverse environmental impacts on National Forest surface resources, including the following requirements:

(f) Roads. Operator shall construct and maintain all roads so as to assure adequate drainage and to minimize or, where practicable, eliminate damage to soil, water, and other resource values. Unless otherwise approved by the authorized officer, roads no longer needed for operations:

(1) Shall be closed to normal vehicular traffic,

(2) Bridges and culverts shall be removed,

(3) Cross drains, dips, or water bars shall be constructed, and

(4) The road surface shall be shaped to as near a natural contour as practicable and be stabilized.

(g) Reclamation. Upon exhaustion of the mineral deposit or at the earliest practicable time during operations, or within 1 year of the conclusion of operations, unless a longer time is allowed by the authorized officer, operator shall, where practicable, reclaim the surface disturbed in operations by taking such measures as will prevent or control onsite and off-site damage to the environment and forest surface resources including:

(1) Control of erosion and landslides;

(2) Control of water runoff;

(3) Isolation, removal or control of toxic materials;

(4) Reshaping and revegetation of disturbed areas, where reasonably practicable; and

(5) Rehabilitation of fisheries and wildlife habitat.

(h) Certification or other approval issued by State agencies or other Federal agencies of compliance with laws and regulations relating to mining operations will be accepted as compliance with similar or parallel requirements of these regulations.

Sec. 228.10 …Unless otherwise agreed to by the authorized officer, operator shall remove within a reasonable time following cessation of operations all structures, equipment and other facilities and clean up the site of operations...

Sec. 228.13

(a) Any operator required to file a plan of operations shall, when required by the authorized officer, furnish a bond conditioned upon compliance with Sec. 228.8(g), prior to approval of such plan of operations. In lieu of a bond, the operator may deposit into a Federal depository, as directed by the Forest Service, and maintain therein, cash in an amount equal to the required dollar amount of the bond or negotiable securities of the United States having market value at the time of deposit of not less than the required dollar amount of the bond. A blanket bond covering nationwide or statewide operations may be furnished if the terms and conditions thereof are sufficient to comply with the regulations in this part.

(b) In determining the amount of the bond, consideration will be given to the estimated cost of stabilizing, rehabilitating, and reclaiming the area of operations.

(c) In the event that an approved plan of operations is modified in accordance with Sec. 228.4 (d) and (e), the authorized officer will review the initial bond for adequacy and, if necessary, will adjust the bond to conform to the operations plan as modified.

(d) When reclamation has been completed in accordance with Sec. 228.8(g), the authorized officer will notify the operator that performance under the bond has been completed: Provided, however, That when the Forest Service

Table 1-1. General Forest Service reclamation requirements.

General Forest Service Mine Reclamation Requirements

has accepted as completed any portion of the reclamation, the authorized officer shall notify the operator of such acceptance and reduce proportionally the amount of bond thereafter to be required with respect to the remaining reclamation.

FOREST SERVICE MANUAL 2800 (FSM 2800) – MINERALS AND GEOLOGY (Selected Provisions)

2840.2 - Objectives. The Forest Service manages the reclamation of lands disturbed by mineral and associated activities in order to:

1. Minimize the environmental impacts resulting from such activities.

2. Ensure that disturbed lands are returned to a use that is consistent with long-term forest land and resource management plans.

2840.3 - Policy

1. Reclamation shall be an integral part of Plans of Operation that propose surface disturbance.

2. All lands disturbed by mineral activities shall be reclaimed to a condition that is consistent with forest land and resource management plans, including applicable State air and water quality requirements.

3. All reclamation requirements included in a Plan of Operations shall include measurable performance standards. Reclamation requirements shall be those reasonable, practicable, and necessary to attain standards.

4. Reclamation shall be undertaken in a timely fashion and occur sequentially with on-going mineral activities.

5. Reclamation bonds, sureties, or other financial guarantees shall ordinarily be required for all mineral activities that require a Plan of Operations; dollar amounts of such guarantees shall be sufficient enough to cover the full cost of reclamation.

6. To the extent practicable, reclaimed National Forest System land shall be free of long-term maintenance requirements.

2840.5 - Definitions

1. Mineral Activities. Any aspect of mineral exploration, development, or production.

2. Reclamation. Those actions performed during or after mineral activities to shape, stabilize, revegetate, or otherwise treat the affected lands in order to achieve a safe and ecologically stable condition and land use that is consistent with long-term forest land and resource management plans and local environmental conditions.

3. Plan of Operations. A written description of planned, on-the-ground mineral activities, including reclamation, to be conducted by the mineral operator for either locatable, leasable, or common variety minerals.

4. Topsoil. Those soil materials useful for the establishment, growth, and perpetuation of vegetal cover on disturbed areas. Such soil materials provide mechanical support for plant root systems and plant nutrients for establishment and growth; useful soil materials may include selected subsoils.

5. Performance Standard. The expected site conditions to be achieved upon completion of reclamation activities.

6. Multiple Bonding. Having more than one bond, surety or other financial guarantee for reclamation on any one

Table 1-1. General Forest Service reclamation requirements.

General Forest Service Mine Reclamation Requirements

mineral operation.

7. Excess Bonding. Where the total amount of bonds, sureties or other financial guarantees exceeds the cost of reclamation.

8. Interim Shutdown. The cessation of mineral activities by the operator prior to the expected time described in the Plan of Operations.

9. Disturbed Area. The surface lands disturbed by mineral or associated activities.

2841 - RECLAMATION COMPONENTS FOR PLANS OF OPERATIONS. Forest Supervisors shall ensure the following administrative and environmental components are adequately addressed in each Plan of Operations when applicable:

1. Administrative Components.

a. Timing, kind, and amount of reclamation to be accomplished concurrently with mineral activities.

b. Reclamation requirements for interim shutdown, including seasonal shutdown.

c. The maximum allowable time in the event of interim shutdown before final reclamation measures will be required.

d. Concurrent and final reclamation of transportation facilities, such as roads, railways, tramways, power line corridors, and pipelines.

e. Removal of facilities and reclamation of the site.

f. Timeframes for periodic review and updating of the Plan of Operations, including reclamation performance requirements and financial guarantees.

g. Procedures for ensuring interim and final stability of waste embankments, including dumps, tailings dams, or impoundments.

2. Environmental Components.

a. Final configuration of the disturbed areas, including such items as roads, pits, waste embankments, ponds, leach pads, drill holes, and facility sites.

b. Revegetation of disturbed areas, including timing, kind, and amount.

c. Topsoil management, including soil salvage and reapplication (FSM 2550 and FSH 2509.15).

d. Air quality management during and after operations (FSM 2580 and FSH 2509.19).

e. Watershed management, including runoff and erosion control, and riparian and wetland protection (FSM 2520 and FSH 2509.15).

f. Water quality management, including physical and chemical characteristics of surface and subsurface water during and after operations (FSM 2530 and FSH 2509.15).

Table 1-1. General Forest Service reclamation requirements.

General Forest Service Mine Reclamation Requirements

g. Visual resource management during and after operations (FSM 2380 and FSH 2309.22).

h. Potential for the occurrence and control of hazardous or toxic substances, including acid mine drainage, that may contaminate air, water or soil.

i. Fish and wildlife habitat reclamation or mitigation (FSM 2630 and FSH 2609.11).

j. Tailings and associated tailings facilities.

k. Stream diversions, reservoirs, ditches, or canals.

2842 - RECLAMATION PERFORMANCE STANDARDS. In addition to a consideration of appropriate reclamation components (FSM 2841), a Plan of Operation shall include measurable performance standards for all reclamation requirements in the plan. Develop performance standards for at least the following.

1. Revegetation.

2. Soil and water conservation measures.

3. Mass stability of overburden or other waste embankments.

4. Concurrent reclamation.

5. Post-mining land configuration.

Regions or Forests should develop Region-wide or Forest-wide reclamation performance standards for common reclamation practices. Use performance standards in determining the amount of the reclamation bond, surety, or other financial guarantee and as criteria for release of these instruments.

2843 - RECLAMATION BONDING. Tie dollar amounts of bonds or other financial guarantees to specific reclamation activities or standards to facilitate full or partial release of the instruments. Release bonds or other guarantees as satisfactory reclamation is performed and completed, and the area stabilized. Avoid multiple or excessive bonding. See FSM 2846 for direction on bonding when other agencies with bonding authority are involved in the administration of mineral activities on National Forest System lands.

2844 - RECLAMATION MONITORING. Regional Foresters and Forest Supervisors shall determine those sites that need monitoring to assess the condition and environmental quality of reclaimed sites following release of bonds or other financial guarantees. Base monitoring priorities on the degree of risk to human health and safety or on long-term environmental effects. Reclaimed sites or structures that might require monitoring include, but are not limited to, revegetated areas, large waste embankments, tailing dams and impoundments, french-drains, stream diversions, dam structures on permanent water impoundments, and water treatment facilities.

2846 - COOPERATIVE AGREEMENTS. Where more than one agency, Federal and/or State, has jurisdiction over a mineral operation, the role of each agency should be defined in a cooperative agreement. The cooperative agreement becomes a primary basis for avoiding multiple and excessive bonding and eliminating conflicting reclamation requirements.

Table 1-2. Monument-specific Forest Service reclamation requirements.

Admiralty Island Reclamation Requirements

Subpart D--Miscellaneous Minerals Provisions

Sec. 228.80 Operations within Misty Fjords and Admiralty Island National Monuments, Alaska.

This section affirms that subpart A of the regulations (§§228.1 to 228.15) applies to mining conducted within the Monument. Additional provisions of this section apply to mine operations but do not specifically address facility reclamation.

Table 1-3. Tongass Forest specific Forest Service reclamation requirements.

Tongass National Forest Reclamation Requirements

TONGASS NATIONAL FOREST LAND AND RESOURCE MANAGEMENT PLAN (TLRMP) (1997)

Note: The majority of Greens Creek's facilities (everything south of the north end of the tailings pile) lie within Admiralty Island National Monument in an area with a Land Use Designation of "Nonwilderness National Monument". The road north of the tailings pile to Young Bay lies outside of the National Monument in an area with a Land Use Designation of "Semi Remote Recreation". As such, the two areas are treated slightly different within the Forest Plan in regards to minerals development and reclamation.

The TLRMP being implemented at the time the reclamation plan was prepared contemplates that (a) disturbed areas will be reclaimed in accordance with an approved plan of operations; (b) reclamation will leave a natural-appearing condition; (c) affected areas will be rehabilitated to minimize the evidence of past mining and to return the area to generally natural conditions, to the maximum extent feasible; and that this is consistent with the project specific reclamation goals as described in the NEPA documents.

General TLRMP reclamation requirements:

"…Reclaim disturbed areas in accordance with an approved plan of operations…."

Semi-Remote Recreation land use designation requirements:

" Approve reclamation plans in which minerals activities leave a natural-appearing condition.

Ensure that landform modifications simulate naturally-occurring forms.

Ensure that disturbed areas are revegetated in accordance with project plans.""

Nonwilderness National Monument land use designation requirements:

" Develop rehabilitation plans following project completion. Include, as needed, rehabilitation of fish and wildlife habitats, soil resources, and the scenery…"

"…After the completion of mining, rehabilitation of the affected areas is done to minimize the evidence of past mining and to the maximum extent feasible, seek to return the area to generally natural conditions. Ultimately, the entire Nonwilderness National Monument provides the same natural settings and recreation experience as the adjacent wilderness National Monument areas…"

Table 1-4. NEPA reclamation requirements.

NEPA Reclamation Requirements

Although the EIS and EA's conducted for the project do not contain enforceable standards, they contain general language about the goals and scope of reclamation activities contemplated during review and approval of the project.

GREENS CREEK FINAL ENVIRONMENTAL IMPACT STATEMENT (1983)

Relevant sections of the Final EIS state:

"…The reclamation plan will include all areas on National Forest land disturbed by the project…"

"Reclamation

1. Reclamation within the monument will be to as near a natural condition as practicable. This will include sealing mine openings, restoring original surface drainage, removal of all structures, recontouring where possible and revegetating all disturbed areas.

2. Reclamation requirements on the non-monument portion of the project area will be determined by the most current TLMP revision at the time of the mine closure. …"

Also see pages 2-57 through 2-60 for general reclamation guidance.

ENVIRONMENTAL ASSESSMENT FOR PROPOSED CHANGES TO THE GENERAL PLAN OF OPERATION FOR THE DEVELOPMENT AND OPERATION OF THE GREENS CREEK MINE ADMIRALTY ISLAND NATIONAL MONUMENT, ALASKA (March 1988)

Reclamation provisions described on page 2-11. Also see pages 4-15 to 4-16 and 4-23, for discussion of reclamation in the context of the then-proposed alternative.

ENVIRONMENTAL ASSESSMENT FOR ADDITIONAL WASTE ROCK DISPOSAL CAPACITY AT GREENS CREEK MINE ADMIRALTY ISLAND NATIONAL MONUMENT, ALASKA (November 1992)

See the reclamation section on pages 30 through 31 and Table 26 on page 96.

Note that alternative 3 was the selected alternative.

The FEIS Record of Decision (ROD) states that reclamation performed within the Monument will intend to return as near a natural condition as practicable. This includes sealing mine openings, restoring original surface drainage, removing structures, re-establishing natural contours where possible, and stabilizing the soils. Stabilizing the soils includes revegetating all disturbed areas, where necessary, and ensuring and maintaining healthy growth.

The ROD states that detailed mitigation, monitoring, and reclamation plans will be included in the Final Operating Plan. The reclamation plan includes all areas on National Forest land disturbed by the project. The plan includes both lands administered by the Admiralty National Monument and Juneau Ranger District (JRD). The reclamation of the Hawk Inlet facility is also covered in this reclamation plan. The privately-owned surface facility is under the jurisdiction of the CBJ and ADNR.

1.4.2. Alaska Department of Environmental Conservation

Mining wastes, except for certain kinds of tailings are categorically exempt from regulation under the Alaska solid waste program 18 Alaska Administrative Code (AAC) section 60.005(b)(8), unless they pose a potential "welfare threat or environmental problem associated with the management of the waste". Recently, ADEC and KGCMC agreed to include production rock Site 23 in the waste disposal permit for which KGCMC had previously applied. Site 23 was included not because it poses an immediate environmental problem, but so that the waste disposal permit would cover its management, even if an environmental problem does not develop. Mining waste is regulated under the monofill standards 18 AAC section 60.455 which allows the department the discretion to incorporate applicable provisions of 18 AAC 60 into a waste disposal permit. A waste that is not specifically addressed in Article 4, such as waste rock, will be classified by the ADEC and assigned the most applicable waste category. The disposal of these wastes is also subject to the requirements of Article 1,2,4,6 and 7 of 18 AAC 60 as necessary to prevent a violation of the air quality standards found in 18 AAC 50 or the water quality standards found in 18 AAC 70.

The waste disposal permit will contain conditions based on applicable provisions of Article 1 and 2 (60.010 to 60.265) that have to do with general standards, limitations, prohibitions and administrative procedures to be followed by every disposal facility regulated under the chapter. Additionally, the waste disposal permit will apply relevant locational, operational, and design related requirements from the monofill standards in Article 4 (18 AAC 60.400 to 60.495) in which the industrial waste standards most closely match the Greens Creek facilities. The monofill requirements also include closure and post-closure care, deed notations, notifications, monitoring and reporting.

According to regulation, financial assurance will be required for closure and post-closure care. The post-closure maintenance and monitoring period that begins after completion of all reclamation activities will extend to a minimum of thirty years, and possibly beyond, as determined at the end of the 30-year period. The permit for the facility will have additional requirements for temporary closure during times when the mine temporarily shuts down and stops the disposal process. Article 7 specifies certain visual, surface water and groundwater monitoring requirements, some of which apply to the post-closure period. Within the detection monitoring subsection, if a significant statistical difference exists between upgradient and downgradient stations or if the water quality standards are exceeded in detection monitoring, then assessment monitoring will be triggered. Assessment monitoring will require that the plume be identified and that the owner/operator identify and implement remedial corrective measures according to 40 Code of Federal Regulations (CFR) 258.55 to 258.58. Lastly, the facilities at Greens Creek are open to waivers to any provision of the chapter under 18 AAC 60.900 upon adequate demonstration and ADEC discretion.

1.4.3. Alaska Department of Natural Resources

Alaska Statute AS 27.19, the Reclamation Act, applies to state, federal, municipal and private land and water subject to mining operations and is administered by the commissioner of the Department of Natural Resources. The Reclamation Act states that "a mining operation shall be conducted in a manner that prevents unnecessary and undue degradation of land and water resources, and the mining operation shall be reclaimed as contemporaneously as practicable with the mining operation to leave the site in a stable condition". An approved reclamation plan and a performance bond are required prior to approval of a mining operation with the exception of certain small operations. The bond amount shall be set at a level not more than an amount reasonably necessary to ensure the faithful performance of the requirements of the reclamation plan. The ADNR cannot require the bond to exceed $750 for each acre of mined land, though 11 AAC 97.420 (c) allows a miner to provide a bond for more than the $750 statutory limit. The commissioner, on a determination that an agreement is in the best interest of the state, may enter into a cooperative management agreement with the federal government or a state agency to implement a requirement of the Reclamation Act or a regulation adopted under it.

Alaska Administrative Code (11 AAC 97 Mining Reclamation) applies to the approval of reclamation plans, reclamation bonding, and enforcement of reclamation requirements under AS 27.19 for locatable mineral, leasable mineral, and material mining operations on state, federal, municipal, and private land. Nothing in the Reclamation Act precludes a federal or state agency (including the Department of Natural Resources), acting under its own regulatory or proprietary authority, from establishing and enforcing additional requirements or higher standards for reclamation. The Reclamation Performance Standards are defined in 11 AAC 97.200 and are summarized in Table 1-5.

Table 1-5. Reclamation requirements of the Alaska Mine Reclamation Act.

Alaska Mine Reclamation Act
LAND RECLAMATION PERFORMANCE STANDARDS (11 AAC 97.200)
(a) A miner shall reclaim areas disturbed by a mining operation so that any surface that will not have a stream flowing over it is left in a stable condition.
(1) For the purposes of AS 27.19.100 (6) and this section, a stable condition that "allows for the reestablishment of renewable resources on the site within a reasonable period of time by natural processes" means a condition that can reasonably be expected to return waterborne soil erosion to pre-mining levels within one year after the reclamation is completed, and that can reasonably be expected to achieve revegetation, where feasible, within five years after the reclamation is completed, without the need for fertilization or reseeding. If rehabilitation of a mined site to this standard is not feasible because the surface materials on the mined site have low natural fertility or the site lacks a natural seed source, the department recommends that the miner fertilize and reseed or replant the site with native vegetation to protect against soil erosion; however, AS 27.19 does not require the miner to do so. Rehabilitation to allow for the reestablishment of renewable resources is not required if that reestablishment would be inconsistent with an alternate post-mining land use approved under AS 27.19.030 (b) on state, federal, or municipal land, or with the post-mining land use intended by the landowner on private land.
(2) If topsoil from an area disturbed by a mining operation is not promptly redistributed to an area being reclaimed, a miner shall segregate it, protect it from erosion and from contamination by acidic or toxic materials, and

Table 1-5. Reclamation requirements of the Alaska Mine Reclamation Act.

Alaska Mine Reclamation Act

preserve it in a condition suitable for later use.

(3) If the natural composition, texture, or porosity of the surface materials is not conducive to natural revegetation, a miner shall take measures to promote natural revegetation, including redistribution of topsoil, where available. If no topsoil is available, a miner shall apply fines or other suitable growing medium, if available. However, a miner may not redistribute topsoil and fines over surfaces likely to be exposed to annual flooding, unless the action is authorized in an approved reclamation plan and will not result in an unlawful point- or non-point-source discharge of pollutants.

(b) A miner shall reclaim an area disturbed by a mining operation so that the surface contours after reclamation is complete are conducive to natural revegetation or are consistent with an alternate post-mining land use approved under AS 27.19.030 (b) on state, federal, or municipal land, or with the post-mining land use intended by the landowner on private land. Measures taken to accomplish this result may include backfilling, contouring, and grading, but a miner need not restore the site's approximate original contours. A miner shall stabilize the reclaimed site to a condition that will retain sufficient moisture for natural revegetation or for an alternate post-mining land use approved under AS 27.19.030 (b) on state, federal, or municipal land, or for the post-mining land use intended by the landowner on private land.

(c) A pit wall, subsidence feature, or quarry wall is exempt from the requirements of (a) and (b) of this section if the steepness of the wall makes them impracticable or impossible to accomplish. However, a miner shall leave the wall in a condition such that it will not collapse nor allow loose rock that presents a safety hazard to fall from it.

(d) If a mining operation diverts a stream channel or modifies a flood plain to the extent that the stream channel is no longer stable, a miner shall reestablish the stream channel in a stable location. A miner may not place a settling basin in the way of the reestablished channel location unless the fines will be properly removed or protected from erosion.

11 AAC 97.240 requires that additional performance standards require that a miner reclaim a mined area that has potential to generate acid rock drainage in a manner that prevents the generation of acid rock drainage or prevents the offsite discharge of acid rock drainage.

1.5. Plan Objectives

The objectives of this plan are to:

- Reclaim mine facilities as soon as practical after disturbance,
- Satisfy all regulatory requirements,
- Protect water quality, and public health,
- Return the site to a near-natural condition to the extent practical,
- Support land uses consistent with the TLRMP especially maintaining fish and wildlife habitat,

- Minimize or eliminate long-term management requirements,
- Ensure long-term stability, and
- Provide a basis for estimating the cost for reclaiming the mine.

A myriad of specific reclamation techniques may be used to accomplish the goals outlined above. Additionally, the technologies available for reclamation are constantly changing as the industry gains collective experience with mine operation and closure. Consequently, the reclamation plan must provide a framework that encourages changes in reclamation technologies, while providing clear guidance on the performance requirements that the plan must achieve. Accordingly, the format of this plan has been developed to define performance goals by describing specific post-closure monitoring requirements, including duration and frequency of inspection or sampling, compliance points, and compliance levels. Specific technologies that will be employed to satisfy these performance goals are the responsibility of KGCMC. A detailed reclamation plan will be submitted and periodically updated by KGCMC as required in Section 1.7.

1.6. Reclamation Schedule

The ultimate reclamation of a mine is often considered during the earliest stages of mine design to ensure that facilities are sited, designed and operated in a manner that is conducive to timely and cost-effective final reclamation. Reclamation activities may occur throughout the life of a mine operation. Five stages of reclamation have been defined for the purposes of this plan as described below.

1.6.1. Interim Reclamation

Interim reclamation includes all actions taken to stabilize disturbed areas during operation of the mine. Generally, the focus of interim reclamation is to reduce erosion and sedimentation of waterways, and to protect water quality.

Techniques used to protect slopes from erosion and to reduce sediment delivery into water courses include various Best Management Practices (BMP's) that are described in more detail in the GPO Appendix 10. Management actions used to protect water quality include surface water diversion, groundwater diversion, and collection and treatment of contact water. These management actions are also described in more detail in GPO Appendix 10.

KGCMC has striven to maintain habitat in its natural condition and improve the habitat in areas where it is feasible. Wildlife has quickly taken advantage of newly created habitats at inactive production rock sites and along the roads that are maintained and improved through interim stabilization seeding. The installation of a fish pass in Greens Creek is an example of an improvement in habitat. The fish pass was originally proposed as mitigation for lost salmon rearing areas because the location and method of surface tailings disposal would have interfered with these areas. Then KGCMC changed how surface tailings disposal has been handled which minimized disturbance to the salmon rearing areas. However, KGCMC still installed the previously proposed fish pass structures to allow salmon access to additional spawning habitat in middle Greens Creek.

KGCMC has routinely performed interim reclamation at inactive sites until final reclamation can be completed, as required by the Forest Service leases and BMP's. Interim reclamation has included hydroseeding and fertilization of disturbed sites to minimize erosion and reduce sediment production in these areas. Maintenance of these areas has achieved the requirements of the leases and BMP's and has resulted in healthy grass and clover growth.

Berms, slope drains, straw bales, silt fences, catch basins, polymers, and hydroseeding have been utilized for temporary erosion control since inception of the mine. When construction is in progress but cannot be completed until the following year, KGCMC removes all temporary culverts and constructs temporary cross drains, drainage ditches, dips, berms, culverts, or other facilities needed to control erosion.

KGCMC strives to implement soil stabilization and erosion control measures in all disturbed and unprotected areas prior to the end of a normal operating season. Work on any additional disturbed areas commences when weather permits or when practical.

1.6.2. Concurrent Reclamation

Reclamation activities should be completed as soon as practical after portions of mine facilities achieve their final grade. Reclamation that is completed while the mine is still in production is termed concurrent reclamation. Concurrent reclamation differs from interim reclamation in that concurrent reclamation is designed to provide permanent, low maintenance achievement of reclamation goals.

Concurrent reclamation is encouraged for many reasons. First, it allows the mine and agencies to measure the performance of specific reclamation technologies before mine closure and to refine the techniques for site-specific conditions. Next, concurrent reclamation reduces bonding requirements. Also, concurrent reclamation for areas of the mine project which are constructed in phases (e.g., tailings pile) can have beneficial effects such as minimizing water infiltration. Additionally, concurrent reclamation facilitates the determination of closure costs. Finally, evaluation of the performance of concurrently reclaimed areas allows for a more accurate assessment of the likelihood that specific reclamation technologies will achieve performance goals.

Generally, for areas in which ARD risk may exist, KGCMC will initiate concurrent reclamation within 6 months of the time that both of the following conditions occur; 1) the performance of reclamation techniques such as the oxygen-excluding cover has been verified by field evaluations and has been found to be effective, and 2) a contiguous area within a facility greater than 2 acres in extent has been brought to its final grade. Five consecutive years of monitoring will be required to verify the effectiveness of the cover. For other areas without a risk of ARD, concurrent reclamation shall be initiated within 6 months of the time that a contiguous area within a facility greater than 2 acres in extent has been brought to its final grade. Before areas may be reclaimed concurrently with mine operation, a detailed reclamation plan must be submitted for Agency review and approval. Plan requirements are described in more detail in Section 1.7.

1.6.3. Temporary Cessation

In the event of temporary cessation of mining activities, KGCMC shall notify the appropriate Agencies in writing at least thirty days prior to any planned suspension or cessation of operations of ninety days or longer. KGCMC shall notify the Agencies of any unanticipated suspension or cessation of operations expected to last more than ninety days or more within ten days of the first day of the temporary closure. The notice shall state the nature and reason for the temporary closure, the anticipated duration of the temporary closure and any event that would reasonably be anticipated to result in either the resumption or abandonment of operations. Project operations must resume for not less than ninety consecutive days in order to terminate the temporary closure status. If a temporary closure extends beyond ten years, the Agencies may deem project operations to be permanently abandoned or ceased, and whereupon final reclamation must commence unless otherwise agreed to by the Agencies. KGCMC shall ensure that the project area is maintained in a safe and secure condition during a temporary closure and KGCMC shall not allow the project area to be degraded or eroded during or as a result of the temporary closure. KGCMC shall continue, in full force, all water collection and treatment, monitoring and reporting required by the reclamation plan unless otherwise agreed to by the agencies.

While the mine operation is inactive, environmental monitoring programs, including the internal monitoring programs described in Appendices 3 and 11 will remain in effect. The need for implementation of interim reclamation activities or final reclamation on components of the mine will be addressed on the basis of environmental monitoring results and consultation with the appropriate agencies.

1.6.4. Final Reclamation

After KGCMC has completed operations at Greens Creek, or at any individual facility or mine unit, then final reclamation can be initiated. When a facility is no longer needed for mine operation or when it has reached its design capacity, then reclamation shall be initiated as soon as practical. It is assumed that at the final reclamation stage, a significant amount of site-specific reclamation experience and performance data will be available. This information will be used to guide development of a site-wide closure plan. Before areas may undergo final reclamation, a detailed plan must be submitted for Agency review and approval. Plan requirements are described in more detail in Section 1.7.

1.6.5. Post-Closure Care and Maintenance

Achievement of many reclamation goals can be expected over a number of years. During the period immediately after final reclamation, the site will be inspected, monitored and managed in a fashion that helps achieve the long-term goals set out in Section 2. Specific management actions that will be employed may depend in part, on the results of post-closure monitoring. The sequence of response actions taken by KGCMC triggered by adverse monitoring results will be described in a detailed contingency plan that will be submitted as part of the final reclamation plan for the mine or if temporary cessation lasts more than 3 years unless otherwise approved by the appropriate agencies.

1.7. Detailed Plan Submission and Approval

A detailed reclamation plan will be submitted periodically by KGCMC. The plan will contain sufficient detail to allow calculation of closure cost including post-closure maintenance and monitoring and to demonstrate that the reclaimed facilities will conform to performance standards, and will describe monitoring to be conducted during the post-closure period.

The first detailed reclamation plan shall be submitted on or before July 1, 2001, unless later submission is authorized in writing by the appropriate agencies. Subsequent updates to the detailed reclamation plan will be submitted at least every five years. The timing of the five-year updates shall be coordinated with the five-year audits that KGCMC and the agencies anticipate having conducted by a third-party auditor, so that information developed during the audits can be taken into account in updating the detailed reclamation plan. More frequent plan revision may be required by the agencies if substantial increases in the disturbed area have occurred since the last reclamation plan revision, or if specific portions of the plan are shown to be incapable of meeting performance goals.

The detailed reclamation plan shall contain preliminary engineering drawings and calculations and a tabulation of material quantities required to complete the reclamation. Additionally, the plan will have a map of the mine area (with detailed maps of Site 23/D, the mill area, the Tailings facility, and other facilities to be reclaimed with an engineered cover) showing final grades, location of channels and diversions, a site access plan, and vegetation type/land use designations. The reclamation plan should also contain a detailed schedule that designates all areas that have been (or will be) concurrently reclaimed by year.

Additionally, a detailed monitoring plan should be developed that identifies how monitoring will be conducted for FWMP sites, internal contact water, and for vegetation establishment. The monitoring plan should describe the sites monitored, the data collected, and the monitoring frequency and duration.

Finally, the reclamation plan shall contain an evaluation of the predicted environmental performance of the facilities that demonstrates that performance goals will be met. The demonstration should consist of previously collected performance data from KGCMC facilities (or from similar sites) that are used as inputs to appropriate models that predict site-specific behavior.

1.8. Final Reclamation Plan and Monitoring/Contingency Plan

Prior to commencement of final reclamation of any facility at the site, KGCMC will submit a final reclamation plan that will be used as the basis for remaining reclamation activities at the site. The final reclamation plan will follow the same format as prior updates of the detailed reclamation plan. The final plan will also include a Monitoring and Contingency Plan that describes in detail what actions KGCMC would follow if the site fails to meet performance goals during the post-closure monitoring period, including long-term contact water management, should that prove necessary. The actions described in the Contingency Plan may be used to determine potential costs that may be associated with the post-closure care and maintenance period. These costs can be used to calculate the amount of bond that needs to be retained after incremental bond release (Section 1.9).

1.9. Bond Cost Calculation and Bond Release

Federal, State and municipal agencies have authority to require financial assurance for performance of reclamation or facility closure and post-closure monitoring activities at Greens Creek. Agencies will coordinate their bonding authority through a memorandum of agreement or other mutually agreeable means. Proof of financial assurance, which may take any form mutually agreed upon by the agencies and KGCMC, is referred to as a “bond” in this section. Unless otherwise agreed between the agencies and KGCMC, the bond amount will be calculated on the basis of detailed reclamation plans submitted by KGCMC pursuant to this appendix.

1.9.1. Incremental Bond Release

A site or area will be eligible for release or partial release of the bond amount directly attributable to that site or area when all pertinent aspects of final reclamation activities are complete, including: removing any facility and necessary materials, grading the surface, applying cover-soils as necessary, and applying the final seed mix. Bond release can be sought for areas reclaimed concurrently (during operation) or after final reclamation.

For a site or area subject to overlapping jurisdiction of the agencies, concurrence from all agencies having jurisdiction over the site or area will be sought as to the completeness of the reclamation. KGCMC will apply for incremental bond release by submitting a letter to the appropriate agencies requesting release of the specific site or area(s). Also, the letter will summarize the conducted reclamation activities, the reclamation activity schedule, and the final revegetation completion date.

The agencies will approve incremental bond release through a process upon which they have agreed. The agencies may require a joint agency/KGCMC site visit to confirm that KGCMC has completed pertinent reclamation activities at the site or area(s). These reclamation requirements will be described in the detailed and final reclamation plans, in the waste disposal permit, and in other applicable permits. If required under the post-reclamation/closure requirements of an applicable permit or approval, KGCMC will continue monitoring the site or area(s) in compliance with applicable permits or approval until the agencies release the entire bond.

1.9.2. Bonding and Management During Post-Closure Care Period

After mining activities are completed in a particular area, KGCMC will return the area to a natural appearing condition using the pertinent procedures described in this Reclamation Plan. After closure, a portion of the site's total bond will be retained for a period to be determined in consultation with the agencies, in light of the applicable post-closure care requirements, to provide for personnel, materials, equipment, and repairs necessary for monitoring, maintenance, and post-closure water management should reclamation maintenance and contingencies become necessary.

If monitoring shows that a site or area is not satisfactorily progressing toward meeting performance goals, KGCMC, will within 60 days of problem identification propose for the agencies' concurrence a written corrective action plan which may require either or both:

- Continued monitoring, with continued retention of the remaining bond amount, over an extended period until progress is made toward satisfaction of the performance goals;

- Implemention of remedial measures to correct the situation delaying or preventing attainment of those goals.

If remedial measures are implemented, KGCMC will, at the discretion of appropriate agencies, restart the monitoring period, which will delay final bond release. The agency holding the bond, in accordance with the agreement among the agencies, may proceed with final bond release if the problems being addressed through remedial measures represent an insignificant proportion of the unreclaimed area compared to the overall success of the reclamation closure.

1.9.3. Final Bond Release

Final release of the remaining bond will occur when monitoring demonstrates that performance goals described in Section 2.0 have been met and any post-closure monitoring required by an applicable permit or approval has been satisfactorily completed. Application for and final bond release will follow the same protocol as described above for incremental bond release. Removal of monitoring equipment will follow the joint agency/KGCMC site visit for confirmation of final bond release.

1.10. Reporting

Starting in 2001, KGCMC shall include in each annual report a tabulation of disturbed acreage and concurrently reclaimed areas (including date), and a description of reclamation activities planned for the following year (provided in the report or in an attached annual workplan for the upcoming year). The report shall also contain a narrative and as-built drawings (in hard copy and in electronic form, if available) that describe the reclamation. Annual reports are submitted to the Forest Service, ADEC and ADNR. Additionally, performance monitoring of concurrently reclaimed areas, and post-closure monitoring results will also be described in annual reports. Additional reporting requirements are described in Section 2.0.

2. Performance Goals

2.1 Water Quality

2.1.1. Monitoring Requirements

The KGCMC Fresh Water Monitoring Program (FWMP) in Appendix 1 of the GPO documents the necessary methods, procedures, analysis, data management, and information to fulfill the water quality monitoring requirements. After closure KGCMC will continue to:

- Sample and analyze groundwater monitoring wells per the latest FWMP schedule.
- Sample and analyze surface water monitoring sites per the latest FWMP schedule.
- Sample and analyze sediment and marine organisms, marine receiving waters and effluent bioassay as long as wastewater discharges continue under the National Pollutant Discharge Elimination System (NPDES) permit.

If practical, remaining monitoring sites that were used in internal monitoring programs at Production Rock Pile 23 and D, the Tailings facility, and at remaining inactive Production Rock piles will also continue to be monitored during the post-closure monitoring period.

2.1.2. Waiver or Modification

Water quality monitoring shall be conducted for not less than 5 years after completion of reclamation activities and not less than 3 years after cessation of collection and treatment of contact water (see Section 2.1.4). KGCMC may, however, request modification of the water quality monitoring requirements at any or all monitoring sites. Modifications may include removal of water quality monitoring stations, reduction in monitoring frequency, or changes in constituents monitored. Request for changes in the monitoring requirements at a facility will be contained in a report that demonstrates that all downgradient monitoring stations have been in compliance with Alaska Water Quality Standards (AWQS) for at least 3 consecutive years. Additionally, results of monitoring at internal sites must corroborate the finding that water quality downgradient of the facility will not change in the foreseeable future. The report will be submitted by KGCMC to the appropriate agencies for their review and approval prior to changing water quality monitoring practices.

This waiver section should be interpreted jointly with waiver provisions contained in the FWMP. Where the waiver provisions contained in this document conflict with the FWMP, these provisions supercede the FWMP.

If a point source discharge permit remains in effect for the components of the mine affected by the request for modification, then KGCMC will also obtain approval for any modifications of the point source discharge permit from the agency or agencies having permit authority for the discharge.

2.1.3. Performance Standards and Point of Compliance

The facilities will be in compliance if 1) all relevant AWQS are met at the downgradient monitoring points specified in Table 2-1, or 2) if accepted detection monitoring statistical analysis, as set out in Section 10 of Appendix 1 (FWMP), applied to the upgradient and downgradient stations fail to show a statistically significant increase in the constituents. These provisions supercede the compliance provisions of the FWMP.

Table 2-1. Proposed compliance monitoring locations for KGCMC facilities.

Facility	**Compliance Points**
Mill Area/920 Portal/1350 Adit	Upgradient - Site 48 (upper Greens Creek) Downgradient - Site 6 (middle Greens Creek),
Production Rock Pile 23/D	Upgradient - Site 6 (middle Greens Creek) Downgradient - Site 54 (Greens Creek below D Pond)
Tailings	Upgradient - Site 58 monitor well MW-T001C (peat), and Site 59 monitor well MW-T001A (till) Downgradient - Tributary creek headwaters / Site 27 monitor well MW-2/shallow (peat), and Site 28 monitor well MW-2/deep (till) Downgradient - West side / Site 29 monitor well MW-3/shallow (peat), and Site 30 monitor well MW-3/deep (till)
All other areas	No specific compliance point identified.

2.1.4. Contact Water Management

During operation of the Greens Creek mine, seepage collected beneath Site 23 and the Tailings facility, and waters that run off of Site 23, Site D, the mill area, and the Tailings facility are collected and treated. Collectively, these waters, known as “contact water”, are collected and treated prior to discharge under an NPDES permit. In order to return the site to a near-natural condition and minimize or eliminate long-term management requirements, KGCMC plans to phase out collection and conventional treatment of contact water. In order to ensure that water quality will be protected after KGCMC ceases to collect and treat contact water, the following requirements shall be satisfied.

- Before KGCMC will be allowed to cease collection and conventional treatment of contact water, a report will be developed by KGCMC for submission to the appropriate agencies. The report will utilize a water quality predictive model of the Production Rock and Tailings facilities to determine whether AWQS will be met at downgradient stations, and will include identification of effective treatment methods. Achievement of AWQS at the compliance point can be by any of the following processes alone or in combination: reduction in ARD or metals loads due to reclamation practices, deployment of demonstrated biological or other non-conventional treatment techniques, or reliance on natural attenuation mechanisms.

- A monitoring plan must be submitted with the report that identifies “early warning” stations that will detect increases in metal loading that represent a precursor to violation of AWQS at the facility compliance point. The monitoring plan shall describe the indicator parameters to be monitored, the monitoring frequency, and duration. Additionally, “trigger levels” shall be proposed at each early warning station that represents levels of constituents that may cause subsequent violation of AWQS at the compliance point.

- The findings of the report, and the monitoring plan are subject to review and approval by the appropriate agencies.

Early warning stations and the downgradient point of compliance shall be monitored for a minimum of 3 years after cessation of collection and treatment of contact water. If violation of the AWQS occurs at the compliance points, or if trigger levels are exceeded at the early warning stations, then KGCMC shall notify the agencies as required by the FWMP. Additionally, a report shall be prepared which describes the potential or observed water quality violation, and will identify probable causes. This report shall be submitted by KGCMC to the appropriate agencies within 30 days of problem identification. A corrective action plan shall be submitted by KGCMC to the appropriate agencies for review and approval within 75 days of the date of problem identification. Following approval of the plan, KGCMC shall implement the plan in a timely manner. The corrective actions to be taken may include, but need not be limited to, changes in the passive treatment system, modification of the water management system, re-establishment of conventional treatment, or improvements to the facility reclamation.

2.2. Demolition

2.2.1. Solid Waste

Structures that have been constructed on Forest Service administered lands will be demolished. All material and equipment will be salvaged and recycled when economically feasible. All hazardous materials will be removed as described in Section 2.2.2 below. Materials that cannot be salvaged will be removed from the site for disposal or disposed on-site in an appropriate manner. If applicable, a solid waste permit will be obtained for on-site disposal of demolition debris.

KGCMC will recover and remove all salvageable equipment, instrumentation, furniture, unused chemicals and fuels, and other salvageable or waste material following permanent closure of the operation. All mobile equipment and other equipment not needed for future potential uses of the site will be salvaged and removed from the site. Removal will consist of loading at the site, transporting to the KGCMC Hawk Inlet facility and offloading to a barge. These materials will either be shipped to buyers, recyclers, or to an approved waste disposal area.

2.2.2. Hazardous Materials

Hazardous materials that remain on-site at the time of final reclamation, whether in the form of unused process reagents, fuels or lubricants, or as residue from demolition of the site (contaminated soil, etc.) shall be removed from Admiralty Island and will be properly recycled or disposed under applicable State and Federal law.

2.3. Land Use/Vegetation

2.3.1. Roads and Site Access

As a part of periodic updates of the detailed reclamation plan and the final reclamation plan that will be submitted by KGCMC to the appropriate agencies, a site access plan will show the roads and trails that are retained after facility closure. Additionally, an approximate time frame for road removal will be developed. Road access will be retained to the Tailings facility, production rock piles, mill area and portal for at least the first five years after closure. Roads will be maintained for longer if necessitated because of continued collection and treatment of contact water (Section 2.1.4). The site access plan shall be developed in a manner that balances the need for economic post-closure care and maintenance and for achieving the goal of returning the site to a near-natural condition.

2.3.2. Aesthetics

The final reclamation plan shall be reviewed by a qualified professional to assess the degree to which the reclamation plan meets the aesthetic goals of the plan. Examples of aesthetic considerations in a reclamation plan may include but are not limited to:

- reduction in the extent of long uninterrupted slope crests with the same elevation,
- design of contours on reclaimed facilities that have crenulations in plan view (e.g. having an irregularly wavy or serrate outline) that approximate those found in surrounding landforms,
- creation of slopes that have a similar profile to those found in surrounding landforms (e.g. concave or convex profiles), and
- integration of natural drainage networks into reclaimed slopes.

Aesthetic considerations may conflict with other performance goals such as stability or environmental performance of engineered covers. Where such conflicts exist, environmental protection shall take precedence over aesthetics.

2.3.3. Revegetation

Disturbed areas at Greens Creek will be reclaimed to one of three vegetation types including upland meadows, upland forest, or wetlands. Specific seed mixtures, woody seedling density, and maps showing each vegetation type will be submitted within the detailed reclamation plan.

Revegetation success will be monitored for three years following seedbed preparation, fertilization, seeding, mulching, and temporary erosion control measures. Fall revegetation surveys will be conducted the first year and a fall survey will be conducted the second and third year. Growth, ground cover, and species survival will be measured and reported on an annual basis. Specific goals for different plant communities are specified in Section 2.3.3.4.

2.3.3.1. Upland Meadow Areas

In all reclaimed areas with slope greater than 25%, the soils will first be stabilized using a hydromulch mixture. A seed mixture containing predominantly native species, to be approved by the Forest Service prior to use, will be broadcast at a rate of 30 lbs pure live seed per acre or other approved rate. Additional native species may be added to the mix to provide cover and variety based upon seed availability and their suitability for hydroseeding. These species may consist of forbs, grass species, blueberries and other food sources that would benefit the wildlife.

Areas reclaimed with grass and forbs on Admiralty Island have shown significant use by a wide range of wildlife species; deer, bear, rodents, raptors, and songbirds. KGCMC will generally limit open meadow areas to 10 contiguous acres to enhance edge-effect, benefit wildlife, improve aesthetics, and advance the rate of succession to the next seral stage.

2.3.3.2. Upland Forest Areas

Forest stands will be developed using a combination of natural regeneration and reseeding or transplanting. Natural regeneration is preferred over planting as a means of establishing a coniferous overstory in small areas where seed sources are available. Natural regeneration will ensure re-establishment of Admiralty Island genotype species, follow natural successional stages, and provide unique wildlife habitat during stand development. Naturally-regenerated plants are well adapted to growing on site. The seeds either migrate from surrounding native plants or, in many instances, are already in the soil. Natural regeneration benefits the environment by ensuring the succession of naturally occurring, site adapted genotype species.

According to an Alaska Forest Management Education Alliance (AFMEA) pamphlet on Forest Regeneration, Alaska has some unique regeneration opportunities that relate to the type of trees and cold soils in Southeast Alaska. The coastal forests of Southeast Alaska regenerate very quickly and profusely. Approximately 95% of disturbed areas seed-in naturally from surrounding stands. Western hemlock and Sitka spruce grow rapidly in this area. Natural regeneration of these climax species is evident throughout areas previously disturbed by KGCMC activities and in areas without any reclamation preparation.

KGCMC will utilize natural regeneration as the primary method of woody plant restoration in areas seeded as upland meadows and in disturbed areas less than 200 feet in their shortest dimension. Accelerated regeneration through seeding will be implemented in more expansive reclaimed areas. Accelerated regeneration would consist of planting more of the climax species to minimize large open areas and accelerate succession.

In areas where the trees propagate either from natural regeneration or from planted seedlings, KGCMC may thin the subsequent growth to allow the remaining trees to grow more quickly and achieve climax forest conditions.

2.3.3.3. Wetland Areas

Wetlands provide food, protection from predators, and other vital habitat factors for many fish and wildlife species. Wetland systems have economic value associated with recreational, commercial, and subsistence use of fish and wildlife resources. In addition, wetlands remove sediment from overland flows before they reach lakes, rivers and bays. Wetlands intercept storm runoff and release floodwaters gradually to downstream surface and groundwater systems. A significant portion of the Greens Creek temperate rain forest setting supports wetlands. Riparian, muskeg, and forested wetland communities all occur in the area.

Final reclamation will provide additional wetland habitats. KGCMC has an agreement with the U.S. Army Corps of Engineers to compensate for wetlands lost during construction by re-establishing and creating additional wetlands. These wetlands will mitigate disturbances and protect the biological productivity for a unique wildlife habitat. KGCMC currently intends to create several wetland sites if the opportunity and conditions are ideal for wetlands. Others will be constructed to maintain adequate hydrology in existing, adjacent, and restored wetlands.

Constructed wetlands will be monitored annually for three years. Permanent vegetation sampling points will monitor plant establishment, growth, and relative abundance.

2.3.3.4. Specific Plant Community Goals

Vegetation on reclaimed areas at Greens Creek shall be subject to the monitoring requirements and performance standards described below. Roads used for permanent access and other areas where buildings are maintained for post-mining use, shall not be subject to vegetation standards.

Vegetation success will be monitored through annual inspections, as well as by surveys of the reclaimed areas in years 1, 2 and 3 following completion of reclamation activities. KGCMC shall submit reports to the Forest Service, ADEC, ADNR and the U.S. Army Corps of Engineers describing the results of these revegetation surveys by the first quarter of the calendar year following completion of annual data collection and monitoring activities. The reports shall include an assessment of vegetation success. Climatic variation and its effects on vegetative growth rates will be considered in this assessment.

Vegetation establishment and success on each reclaimed facility shall be monitored through the establishment of transect lines. Transect locations for all reclaimed areas shall be selected by KGCMC in consultation with the appropriate agencies. Vegetation inspections of all reclaimed areas shall follow the following guidelines:

- Visual inspections of vegetation cover by life-form will be conducted (including annual grass, perennial grass, forbs, shrubs, trees, litter and standing dead.) Evidence of dieback, subsidence, slope failures or erosion will be noted.

- Inspections will be conducted on permanent transects.

- Pedestrian traffic will be restricted to the downhill side of the transect line and people will not be allowed to walk on the plots.

- Vegetation monitoring will be conducted once each year during peak standing biomass.

Revegetation efforts shall be considered successful when the following conditions are met:

- The total vegetative cover (including live biomass of perennial species, litter, and standing dead) in each revegetated area is equal to or exceeds 80 percent aerial cover, with a 90 percent statistical confidence limit;

- The density of actively growing trees is within 80 percent of target levels contained in the approved reclamation plan with a 90 percent statistical confidence;

- The reclaimed wetland and plant meadow areas have at least three graminoids present each with relative herbaceous cover value equal to or greater than 5 percent, with no one graminoid comprising more than 70 percent relative cover;

- The reclaimed upland forest areas have at least two species of trees and one species of shrubs present, with each species comprising no less than 5 percent or no greater than 95 percent of the relative density value.

If vegetation monitoring indicates that, due to natural or other causes, a reclaimed area does not exhibit the potential to achieve the revegetation standards described above, a report shall be prepared which describes the area in question, the situation as identified, probable causes, and a corrective action plan. This report shall be submitted by KGCMC to the appropriate agencies within 60 days of problem identification. Following approval of the plan by the appropriate agencies, KGCMC shall implement the plan in a timely manner. The corrective actions to be taken may include, but need not be limited to, re-establishment of topsoil thickness, reseeding, and replanting of trees and shrubs.

2.3.4. Wildlife Use

KGCMC will conduct qualitative wildlife species counts to monitor wildlife habitat utilization and wildlife habitat potential of the reclaimed areas. These counts will be conducted and reported on an annual basis.

2.4. Stability

2.4.1. Mass Instability

Semi-annual inspections of all reclaimed areas for evidence of slope instability shall be made in year 1. Annual inspections will be made in years 2, 3 and 5 following completion of reclamation activities. Additionally, Site 23/D, the Tailings Facility, and other facilities reclaimed with engineered covers will be monitored every five years for the duration of the post-closure mandatory period specified in the waste disposal permit. KGCMC shall submit a slope-stability report to the appropriate agencies, summarizing the findings of the periodic inspections.

- Development Rock Piles: The slopes and benches of the waste rock pile shall remain in a stable condition.
- Underground Mine: The portal area and stopes within 50 feet of land surface shall be monitored for signs of geotechnical instability.
- Tailings Pile: The slopes and benches of the tailings pile shall remain in a stable condition.
- Other Reclaimed Areas: The slopes of other areas throughout the permit area, including the mill area, borrow areas, reclaimed exploration roads, access roads, and other support facilities shall remain in a stable condition.

Mass instability, including slope failure and subsidence in the above areas, shall be subject to the contingency requirements described below.

Production Rock Pile: If slope movement, subsidence, erosion or other mass instability which threatens the performance of the reclaimed soil cover occurs, KGCMC shall notify the appropriate agencies within two business days of problem discovery, and shall take timely action to prevent excessive entry of surface water into the pile. Additionally, a geotechnical investigation shall be conducted, and a report describing the cause of the failure and appropriate remedies for completing necessary repairs and for preventing future slope movement shall be submitted by KGCMC to the appropriate agencies for review. After review and approval of the plan by the appropriate agencies, KGCMC shall implement the corrective measures described in the plan in a timely manner.

Underground Mine: If crown pillar failure occurs over any stopes, or if development headings collapse near the portal, KGCMC shall notify the appropriate agencies within two business days of problem discovery, shall conduct a geotechnical investigation to determine the cause of such failure and shall propose a corrective action plan for review. After review and approval of the plan by the appropriate agencies, KGCMC shall implement the approved plan in a timely manner.

Tailings Pile: If slope movement, subsidence, erosion or other mass instability is observed in the tailings pile, KGCMC shall notify the appropriate agencies within two business days of problem discovery. A geotechnical investigation shall be conducted to ascertain the extent of the problem, and a report describing the situation as identified, including estimates of the volume affected by the instability and potential consequences of the instability with respect to its affect on the integrity of the cover system and drainage features, shall be developed by KGCMC and submitted to the appropriate agencies within 30 days of the date of problem identification. A corrective action plan shall be submitted by KGCMC to the agencies for review and approval within 75 days of the date of problem identification. Any remedial measures undertaken in conjunction with the corrective action plan shall be completed in a timely manner, which minimizes disturbance to reclaimed areas and meets all original design criteria for the tailings pile.

Other Reclaimed Areas: If slope movement, subsidence or other failure which threatens the integrity of any other reclaimed area occurs, KGCMC shall notify the appropriate agencies within 30 days of problem discovery and shall repair any damage that could affect other reclaimed facilities in a timely manner.

2.4.2. Permanent Channels and Channel Inspection

Surface water flows will be managed in most cases by establishing vegetative cover and constructing moderate slopes. Most slopes will be constructed with a 3H:1V slope. Constructing slopes at 3:1 reduces the erosive effects of water. In areas with minor flow concentrations, straw bales, silt fences, and swales will be used to reduce the velocity of the water and reduce erosion while vegetation becomes established. Also, hydroseeding of these areas will stabilize the soils.

If natural stream channels enter reclaimed areas the water will be diverted, diffused, or channeled through the reclaimed area using designed and constructed non-erosive channels. Stream channels will be stabilized with degradable fiber mat to establish vegetation. Riprap will be used to stabilize the constructed channels in areas that are subject to highly erosive stream flows.

All drainage channels and diversion structures installed during reclamation of the Greens Creek Mine shall be designed to handle flows from a 24 hour/25 year storm event, at a minimum, and shall be subject to the routine inspection and maintenance requirements described below.

In order to ensure that the drainage channels and diversion structures are functioning properly, they shall be inspected semi-annually for signs of excessive erosion for five years following completion of reclamation activities. After the first two years of monitoring, KGCMC may propose to the appropriate agencies that inspection be conducted less frequently if appropriate. During the five year period, drainage channels and diversion structures shall be inspected within 24 hours following storm events in excess of 2 inches of rainfall for signs of deterioration and erosional damage as well as sedimentation.

During the remainder of the post-closure monitoring period required under the waste disposal permit, drainage channels and diversion structures shall be inspected after each storm event that exceeds the largest prior storm that has occurred since completion of reclamation. The appropriate agencies may require more frequent inspection by KGCMC during the post-closure monitoring period if the drainage channels and diversion structures are shown to require frequent maintenance or repair.

Routine inspections and inspections completed after major storm events shall be subject to the following requirements:

- Physical damage, trash build-up and sedimentation shall be recorded on field inspection sheets.
- Diversion intake and outflow areas shall be inspected for evidence of scouring or bypass.
- Any areas needing maintenance or repair shall be reported on the field inspection sheets.

If damage is noted, appropriate repairs shall be completed by KGCMC in a timely manner. A summary of all observed damage requiring repair shall be submitted annually to the appropriate agency, including as-built reports verifying the completion of the required repair.

If significant damage or overflow is caused by storms that are smaller than the structure's design storm, KGCMC shall conduct an investigation to identify the cause of significant damage or overflow of diversions. A report shall be prepared by KGCMC identifying the extent of the problem and the probable causes. The report shall be submitted to the appropriate agencies within 30 days of the date of problem identification. A corrective action plan shall also be submitted to the appropriate agencies for review and approval within 75 days of the date of problem identification. The corrective actions to be taken may include, but need not be limited to, regrading, armoring of drainage features, re-design and re-construction of channel cross-section and alignment, replacement of topsoil, reseeding, and replanting of trees and shrubs. After approval by the appropriate agencies, KGCMC shall implement the plan in a timely manner.

2.4.3. Drainage

The surface of the reclaimed facilities shall be maintained in a free-draining condition, which allows water to egress the facility without ponding or causing erosion, to the extent practical.

If significant ponding of water occurs on the surface of any non-wetland reclaimed facility, KGCMC shall notify agencies within two business days of the date of problem identification. In addition, the extent of such ponding will be ascertained and a report describing the situation as identified, including probable causes, shall be developed by KGCMC and submitted to the agencies within 30 days of the date of problem identification. A corrective action plan shall be submitted by KGCMC to the agencies for review and approval within 75 days of the date of problem identification. Following approval of the corrective action plan by the agencies, KGCMC shall implement the plan in a timely manner. The corrective actions to be taken may include, but need not be limited to, the following steps:

- placement of additional fill that meets original design criteria.
- regrading of placed fill to original design criteria.
- placement of growth medium to original design thickness.
- reseeding/planting as per original design specifications.

Any such remedial measures shall be undertaken in a manner that minimizes disturbance to adjacent reclaimed areas.

2.4.4. Cover Performance and Inspection

2.4.4.1. Cover Performance

Field instrumentation will be installed to monitor performance of engineered covers used at KGCMC. The installation includes the following components:

- A weather station for measuring precipitation, net radiation, relative humidity, temperature, and wind speed.
- Thermal conductivity sensors to measure soil suction and temperature.
- Lysimeters to measure infiltration rates.
- Neutron Probe access tubes for monitoring water content profiles at selected locations on the site.

Construction details for the installation of the instrumentation is shown in the USEL Waste Rock Cover Design Final Report (1998). KGCMC proposes to monitor cover performance for 5 years beginning with installation of the Site 23 cover. KGCMC will determine from these monitoring results whether to propose additional cover performance test monitoring in which instrumentation will be installed at other selected cover sites. The monitoring approach is subject to review and approval by the appropriate agencies.

2.4.4.2. Cover Inspection

In order to ensure that the cover systems are functioning properly, they will be inspected semi-annually for five years following completion of reclamation activities for signs of excessive erosion, damage due to blow-down of trees or damage by animals. Excessive erosion is defined to be erosion that has exposed or threatens to expose any low permeability layer or oxygen excluding layer due to removal of soil. After the first two years of inspection, KGCMC may propose to the appropriate agencies that inspection be conducted less frequently, if appropriate. During the five year period, the cover system, diversion structures and drainage channels shall also be inspected by KGCMC within 24 hours following storm events in excess of 2 inches of rainfall for signs of deterioration and erosional damage as well as sedimentation. Any necessary repairs shall be completed by KGCMC in a timely manner.

If levels of erosion which are potentially destructive to the low permeability or oxygen excluding layer are identified, KGCMC shall notify the appropriate agencies within two business days of the date of problem identification. In addition, the extent of the problem will be ascertained and a report describing the situation as identified, including probable causes, shall be developed by KGCMC and submitted to the agencies within 30 days. A corrective action plan shall be submitted to the agencies for review and approval within 75 days of the date of problem identification. Following approval of the corrective action plan, KGCMC shall implement the corrective action plan in a timely manner. This work may include, but need not be limited to, regrading, armoring of drainage features, re-establishment of topsoil thickness, reseeding, and replanting of trees and shrubs.

If the cover system is breached by rodents and/or other digging wildlife, the extent of the problem will be ascertained and a report describing the situation as identified, including probable causes shall be developed by KGCMC and submitted to the appropriate agencies within 30 days of the date of problem identification. A corrective action plan shall be submitted to the agencies for review and approval within 75 days of the date of problem identification. Following approval of the corrective action plan, KGCMC shall implement the plan in a timely manner. If removal and/or relocation of animals is required, State of Alaska and Forest Service biologists shall be consulted regarding the removal/relocation process. In the event of an emergency need to remove or relocate animals when no biologist is available for consultation, KGCMC shall consult with qualified wildlife biologists and submit a summary report of the actions taken to the agencies.

Repair of the low permeability layer shall include, but need not be limited to, the following steps:

- removal of growth medium from the affected and immediately adjacent area and stockpiling.
- removal of the damaged areas of the low permeability layer or oxygen-excluding layer.
- re-installation of the cover components in affected areas to the design performance criteria under the same QA/QC procedures as the original installation. The edges of the re-installed layers will overlap with the adjacent undisturbed layers to assure adequate joining of the layers.
- replacement of overlying cover layers to their original design thickness.
- reseeding/planting as per original design specifications.

All such repairs shall be undertaken in a manner that minimizes the disturbance to the surrounding reclaimed area. KGCMC shall submit an as-built report of the work performed under the corrective action plan to the agencies.

2.4.5. Erosion

All reclaimed areas shall be inspected semi-annually for five years following completion of reclamation activities for signs of excessive erosion. After the first two years of monitoring, KGCMC may propose to the appropriate agencies that inspection be conducted less frequently if appropriate. Routine monitoring shall include a visual assessment of rills and gullies.

Erosion of applied cover-soil from the production rock piles or tailings pile shall not expose significant contiguous areas of low permeability or oxygen excluding layers or otherwise be allowed to significantly decrease the performance of the reclaimed soil cover in minimizing infiltration into the pile.

Erosion of applied cover-soil from reclaimed roads, borrow areas, the mill area, and other reclaimed areas shall not be permitted to significantly decrease the performance of the reclaimed soil cover in supporting vegetation.

If erosion features deeper than 8 inches develop, KGCMC shall repair the damaged areas in a timely manner. If large numbers of significant erosion features are evident during an inspection period (more than 25 rills per acre over an area of 1 acre or more), then a mitigation plan to prevent recurrence of the erosion shall be developed, submitted for agency review and approval, and implemented by KGCMC. Elements of such a mitigation plan may include, but need not be limited to, regrading or otherwise re-directing surface runoff away from the affected areas.

If potentially destructive levels of erosion are identified, KGCMC shall notify the appropriate agencies within two business days. In addition, KGCMC shall determine the extent of erosion and shall submit a report describing the situation identified and probable causes to the appropriate agencies within 30 days of the date of problem identification. A corrective action plan shall be submitted by KGCMC to the appropriate agencies for review and approval within 75 days of the date of problem identification. Following approval of the corrective action plan, KGCMC shall implement the plan in a timely manner. This work may include, but need not be limited to, regrading, armoring of drainage features, re-establishment of topsoil thickness, reseeding, and replanting of trees and shrubs.

Reclamation Bond

The reclamation bond will be recalculated when the Record Of Decision has been issued to reflect the selected alternative.

Appendix D

ADEC Waste Management Permit, 2003

STATE OF ALASKA

FRANK H. MURKOWSKI, GOVERNOR
610 University Avenue
Fairbanks, AK 99709-3643
PHONE: (907) 451-2360
FAX: (907) 451-2187
http://www.state.ak.us/dec

DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF AIR AND WATER QUALITY
WASTEWATER DISCHARGE PROGRAM

November 7, 2003

Mr. William Oelklaus
Kennecott Greens Creek Mining Company
PO Box 32199
Juneau, Alaska 99803

Subject: Waste Management Permit 0211-BA001 (replaces 0111-BA001)
Kennecott Greens Creek Mining Company

Dear Mr. Oelklaus:

The Alaska Department of Environmental Conservation has completed its evaluation of your request to continue disposing of treated tailings from a zinc, lead, silver and gold recovery facility to a lease area with an increased footprint to a total of 123.3 acres (inclusive of disposal area and treatment infrastructure adjacent to the disposal area) and various portions within the underground workings of the mine, and the disposal of waste rock (also known as production rock) to production rock disposal sites 23 and D. The above-ground tailings facility is projected to accept tailings up to a final projected total tailings footprint area of 62.2 acres and total volume of 5.3 million cubic yards (9.6 million tons). The facility includes a marine outfall with diffuser that is used for discharge of waters from the facility under an NPDES permit. The above ground production rock facility has a total capacity of 1.2 million cubic yards.

This permit is issued under the provisions of Alaska Statute 46.03, and the Alaska Administrative Code, 18 AAC 15, 18 AAC 60, 18 AAC 70, and 18 AAC 72 as amended or revised and, other applicable state laws and regulations, and references portions of the mine's the General Plan of Operations (GPO). Please review the conditions and stipulations in this permit and ensure that they are all understood. This permit is effective November 7, 2003 and expires November 7, 2008.

Any person who disagrees with this decision may request an adjudicatory hearing in accordance with 18 AAC 15.195- 18 AAC 15.340 or an informal review by the Division Director in accordance with 18 AAC 15.185. Informal review requests must be delivered to the Division Director, 555 Cordova Street, Anchorage, AK 99501, within 15 days of the permit decision. Adjudicatory hearing requests must be delivered to the Commissioner of the Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska 99801, within 30 days of the permit decision. If a hearing is not requested within 30 days, the right to appeal is waived.

Sincerely,

William D. McGee
Technical Engineer

Enc.:
Permit 0211-BA001
Response to Comments

cc:

Rich Heig, Kennecott Greens Creek Mining Co.
Ed Emswiler, ADEC, Juneau
Kenwyn George, ADEC, Juneau
Jim Durst, ADF&G, Fairbanks
Joe Donohue, ADNR, Juneau
Stan Foo, ADNR, Anchorage
Steve McGroarty, ADNR, Fairbanks
Jim Vohden, ADNR, Fairbanks
David Cohen, ADNR, Lands, Juneau
Cam Leonard, ADOL, Fairbanks
Dale Pernula, CBJ, Director of Planning
Teri Camery, CBJ, Coastal District Coordinator, ACMP
Dave Chambers, Center for Science in Public Participation
Amy Crook, Center for Science in Public Participation
John Leeds, COE
Steve Hohensee, USFS / Juneau
Cindy Godsey, EPA
Page Else, Sitka Conservation Society
Ruth Hamilton Heese, Robertson, Monagle & Eastaugh
Kat Hall, SEACC
Buck Lindekugel, SEACC
Tim Obst, USDA - OGC
Pete Griffin, USFS / Juneau
Jeff DeFreest, USFS / Juneau
Dave Cox, USFS / Juneau
Forrest Cole, USFS / Ketchikan
Deborah Rudis, USFWS
Theresa A.N. Woods, USFWS
Mac McLean, ADNR

STATE OF ALASKA
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
610 UNIVERSITY AVE.
FAIRBANKS, AK 99709-3643

WASTE MANAGEMENT PERMIT

Permit 0211-BA001 **Date: November 7, 2003**

This Waste Management Permit is issued to the Kennecott Greens Creek Mining Company, POB 32199, Juneau, Alaska 99803, for the disposal of mine tailings and other solid wastes as defined in Section 2.1 of this permit, from a zinc, lead, silver and gold recovery facility to a lease area of 123.3 acres (inclusive of tailings disposal area and treatment infrastructure adjacent to the disposal facility) located within Sections 22, 23, 26, and 27, T.43S., R.65E., CRM, and the disposal of waste rock (also known as production rock) to production rock disposal sites 23 and D, located within the SW ¼ Section 4, & SE ¼ Section 5, T.44S., R.66E., CRM. Additionally, this permit allows for the disposal of tailings, production rock and other solid waste as defined in Section 2.1 to various locations within the underground workings of the mine. The above-ground tailings facility is projected to accept tailings up to a final projected total tailings footprint area of 62.2 acres and total volume of 5.3 million cubic yards (9.6 million tons). The facility includes a marine outfall with diffuser that is used for discharge of waters from the facility under an NPDES permit. The above ground production rock facility Site 23 has a total capacity of 1.2 million cubic yards covering 18 acres. The above ground production rock facility Site D has a total capacity of 210,000 cubic yards of production rock on the 8 acre site. Site D has been filled to capacity. This permit is issued under the provisions of Alaska Statute 46.03, and the Alaska Administrative Code, 18 AAC 15, 18 AAC 60, 18 AAC 70, 18 AAC 72 as amended or revised, and other applicable state laws and regulations. This permit is effective November 7, 2003 and expires November 7, 2008. It may be terminated or modified in accordance with AS 46.03.120.

This permit is subject to the conditions and stipulations contained in the following sections and appendices:

This permit references those portions of Appendices 1, 3, 11, and 14 of the General Plan of Operations that are applicable to the Tailings facility, Production Rock sites 23 and D, and the underground facilities. Changes to those portions in these Appendices must be approved by the Department if they affect this permit. If the Department does not agree with changes made after the effective date of this permit, the conditions of this permit will remain in effect. If there is a conflict between the GPO and the regulations or this permit, then the regulations or the permit, as the case may be, take precedence unless otherwise specified.

This permit may be modified to include other mine related disposal areas or waste materials if the Department determines that there is an environmental problem associated with the management of those areas or waste materials.

Unsaturated Soils Engineering, Ltd. (USE) designed the final cover for the waste disposal sites (Waste Rock Cover Design, dated December 23, 1998). This permit approves design profile #4, or any approved modification to this design, or any other cover that the Department determines will provide equal or better protection of the environment.

The permittee shall conduct post-closure care and monitoring for 30 years for the facilities under section 2.5 of this permit and according to 18 AAC 60.490(c). The need for additional post closure care and monitoring shall be assessed at the end of the post-closure care period. At the end of the post-closure period, the Department will determine whether post-closure care and monitoring should be extended. The marine outfall with diffuser for the facility is required to be bonded in accordance with Section 9.1 for 50 years in the case post-closure maintenance and monitoring is necessary.

This permit waives the following regulatory requirements:

1. 18 AAC 70.020. The requirement for ground water samples to be Total Recoverable for metals. Total recoverable will be required only if the Dissolved analysis shows the water quality to be at the point of or closely approaching the state water quality standards.
2. 18 AAC 60.243. This requires intermediate cover to be placed within 7 days after the waste is last deposited in that area, using a soil material at least 12 inches thick, graded to prevent water from ponding. This requirement is waived based on the nature and management of the materials being deposited and engineering review has confirmed its geotechnical stability.
3. 18 AAC 60.485(c). This requires a minimum slope of 3H:1V be used to ensure slopes are stable and do not erode or slough. This requirement is waived for the slope at production rock site #23 during construction. The slope at the production rock site #23 is designed and constructed to a 2.85(H):1(V). Benches will be used to ensure stability and monitoring will be done to ensure this. At closure, slopes shall be made to 3H:1V if necessary in order to maintain stability.
4. 18 AAC 60.820. This is a requirement for groundwater monitoring. At production rock site D, groundwater monitoring is limited to one well below site D to the southeast of the site. Additional groundwater monitoring below the site is waived because of the difficulty of locating wells in the area adjacent to Greens Creek. In lieu of groundwater monitoring, the

Greens Creek river, into which the groundwater discharges, will be monitored for chemicals and metals; in addition to biological monitoring.

William D. McGee
Technical Engineer

1 LIMITATIONS AND PROHIBITIONS

1.1 WASTES PROHIBITED.

The following materials may not be disposed into either surface or underground facilities, unless otherwise provided:

1.1.1 laboratory wastes and discarded, unused chemicals,

1.1.2 polluted soils, spill boom, liners used for the containment of spilled materials, chemicals used in the cleanup of spills or other spill clean up wastes,

1.1.3 uncombusted household waste,

1.1.4 sewage solids that are untreated and/or have less than 10% solids by weight,

1.1.5 asbestos waste,

1.1.6 hazardous wastes, as defined by 40 CFR Part 261, including radioactive material, explosives, oil, solvents, strong acids, untreated pathogenic waste,

1.1.7 glycol and solvents, and,

1.1.8 tires (prohibited from above ground disposal only), fuels, oil filters, transformers, paint, equipment and packing material.

1.1.9 Class 4 production rock disposal is prohibited at the surface facilities unless authorized in writing by the Department.

2 ITEMS APPLICABLE TO SURFACE WASTE DISPOSAL FACILITIES

2.1 TYPES OF WASTE ALLOWED

2.1.1 Mill tailings are allowed at the tailings disposal facility

2.1.2 Production rock is allowed at Site 23 and Site D, as well as at the tailings disposal facility

2.1.3 Up to five percent of the waste in the tailings disposal facility or Site 23 may be non-hazardous incidental wastes which may include the following:

2.1.3.1 settled solids from sumps, ditches, and degritting basins;

2.1.3.2 settled solids from the pit 5 water treatment plant (tailings area only)

2.1.3.3 dewatered sewage sludge (tailings area only);

2.1.3.4 incinerator ash and residue (tailings area only);

2.1.3.5 ash from the combustion of scrap wood material, and cardboard waste;

2.1.4 Incidental production and/or salvage rock to create access roads and to provide surface erosion control.

2.1.5 Other wastes may be disposed only with written approval of the land manager and the Department.

2.2 GENERAL REQUIREMENTS.

The permittee shall construct, operate, close, maintain and monitor the facility to:

2.2.1 prevent disposal of waste materials from exceeding the design capacity of the disposal facilities,

2.2.2 minimize run-on water from entering the facility from upgradient sources of surface and ground water. Any changes in the phreatic water surface level shall not interfere with the pile geotechnical stability,

2.2.3 control and treat surface water, ground water and leachate as necessary to prevent off-site water quality exceedance,

2.2.4 not cause a violation of 18 AAC 70 water quality regulations at or beyond all points of compliance,

2.2.5 not place solid waste in water,

2.2.6 control solid waste from washing away from the facility, using Best Management Practices,

2.2.7 minimize the infiltration of water and oxygen during the routine operations, closure, and post-closure care periods,

2.2.8 design and construct to ensure geotechnical stability of waste materials and cover systems,

2.2.9 minimize the potential for liquefaction within the facility in the event of a design basis earthquake (DBE) event for operations (crustal earthquake 1/475 year at magnitude 6.5), and a maximum design earthquake (MDE) at closure (equal to 75% of maximum credible earthquake, magnitude 7.0),

2.2.10 minimize the potential for development of acid rock drainage conditions within the facility, 2.2.11 control wind-blown airborne particulate dispersion, and,

2.2.12 after the placement of all Class 4 production rock underground, maximize the placement of Class 3 production rock and tailings underground to the greatest extent practical.

2.3 TEMPORARY CLOSURE

2.3.1 Temporary closure is defined as the period between 90 days and 3 years during which there has been a cessation of mining and milling activities. The length of time for a temporary closure may be extended beyond 3 years by written authorization from the Department.

2.3.2 KGCMC shall notify the Department in writing at least thirty days prior to any planned temporary closure of 90 days or longer. KGCMC shall notify the Department of any unanticipated temporary closure expected to last ninety days or longer within ten days after the first day of the temporary closure. The notice shall state the nature and reason for the temporary closure, the anticipated duration of the temporary closure, and any event that would reasonably be anticipated to result in recommencement of operations. Operations must resume for not less than ninety consecutive days in order to terminate the running of the temporary closure period.

2.3.3 The permittee shall submit a conceptual temporary closure plan to the Department for approval within 30 days after shutdown of all mill processes.

2.3.4 The permittee shall submit a detailed temporary closure plan to the Department within 60 days after shutdown of all mill processes. The permittee is encouraged to submit the detailed plan as early as possible within the 60 days. The detailed plan shall include the following:

2.3.4.1 procedures, methods, and schedule for the collection, treatment, disposal or storage of leachate,

2.3.4.2 management practices designed to control surface and ground water drainage to and from the facility and the surrounding area,

2.3.4.3 secure storage of chemicals during the period of closure, and,

2.3.4.4 management practices designed to minimize oxygen and moisture entry into the waste.

2.3.5 The Department shall have 15 days to review and approve, or to request modifications to, the temporary closure plan. Full implementation of the temporary closure plan is required once approved. The plan can be modified by submitting a revision to the Department for approval.

2.3.6 During the temporary closure period, the permittee shall:

2.3.6.1 continue monitoring and reporting activities as if the facility were actively accepting waste, and,

2.3.6.2 complete concurrent reclamation on all areas that have achieved final elevation, except to the extent that completion of concurrent reclamation would impair the ability to perform work on adjacent areas upon recommencement of operations, and satisfy corrective action requirements as appropriate under this permit and the Reclamation Plan.

2.4 PERMANENT CLOSURE

The permit holder shall:

2.4.1 Within 180 days of the USDA Forest Service approving the lease boundary expansion and GPO amendment request based upon their Record of Decision (ROD) for the "Greens Creek Tailings Disposal" FEIS, dated November 2003, submit to the Department updated closure and post-closure plans for all facilities covered under this permit, which provides a detailed, site-specific and task-specific component of the Reclamation Plan. This plan shall include a preliminary analysis of the options that will effectively treat contact water after closure of the facilities, as well as a detailed submittal of the best available treatment option or options at that time. The analysis will address differing water flow volumes and pollutant concentrations that may reasonably be expected. This analysis may be ongoing throughout the life of the facility. Updates shall be submitted with the annual report when significant changes in the available technology have occurred such as for the Sulfate Reduction Monitoring Program (SRMP).

2.4.2 at least 60 days prior to the renewal of this permit, submit an updated closure plan in the form described above, in conjunction with the 5 year facility audit.

2.4.3 submit an updated closure plan to the Department with the annual report if there are changes made to the closure plan during any year of operation.

2.4.4 notify the Department of any changes to the closure plan at least 30 days before the site is to be permanently closed and/or the equipment withdrawn.

2.4.5 initiate final closure activities within 3 years to those areas that have reached final elevation and in which the intent is not to place future waste. Final closure for these areas may be extended beyond 3 years only with Department approval.

2.4.6 submit updated, detailed, cost-biddable, reclamation and monitoring plans for approval within 90 days of the decision that permanent cessation of the mill process will occur. These updates must describe the manner in which reclamation and monitoring will take place and set standards for evaluating the success of the reclamation in light of the conditions existing at the facility at the time of closure. This plan will include a sequence-of-events schedule that is as specific as feasible.

2.4.7 complete the installation of the engineered cap and commence revegetation as part of closure within 2 construction seasons after initiation of site closure as specified in Section 2.4.5 of this permit unless otherwise approved.

2.4.8 Within 2 years from the issuance date of this permit, conduct a qualitative and quantitative study performed by a qualified plant or soil scientist that addresses long-term issues related to tree blow-down on the final cover system. Incorporate findings into reclamation plan as appropriate. The study shall provide reliable information on whether or not tree blow-down may cause deterioration of the integrity of the final cover system over time or change any of the design assumptions.

2.4.9 Cosure of the facility shall require:

2.4.9.1 use profile #4 soil cover design as detailed in the Waste Rock Cover Design dated December 23, 1998 by Unsaturated Soils Engineering Ltd., or any modification to these designs, or any alternative cover, that the Department determines provides equal or better environmental protection,

2.4.9.2 installation of the cover system so that it functions properly according to the design 30 years after the facility is closed in its entirety,

2.4.9.3 monitoring and documentation of the final cover system and pile for the parameters found in 2.12.8.1 through 2.12.8.4 of this permit throughout closure and post-closure care,

2.4.9.4 construction of all outside slopes shall be no steeper than 3H:1V, except as otherwise specified by this permit.

2.4.9.5 stable slopes with no indication of sloughing or erosion,

2.4.9.6 effective run-on and run-off controls to handle a 25-year, 24-hour storm event,

2.4.9.7 minimization of leachate flows from the facility through the use of passive capping management practices,

2.4.9.8 compliance with State of Alaska water quality standards at all points of compliance, and, 2.4.9.9 revegetation in accordance with those requirements of the approved reclamation plan according to the GPO.

2.5 POST-CLOSURE CARE

2.5.1 Post-closure care shall begin after it is determined that closure is complete. Closure shall be deemed complete when the requirements of section 2.4 of this permit are met.

2.5.2 At least 180 days prior to closure of the facility, a post-closure care and monitoring plan shall be submitted to the Department for approval.

2.5.3 The permittee shall conduct post-closure care and monitoring for 30 years according to 18 AAC 60.490(c). The need for additional post-closure care and monitoring shall be assessed at the end of the post-closure care period. At the end of the post-closure period, the Department will determine whether post-closure care and monitoring should be extended.

2.5.4 The permittee shall:

2.5.4.1 prepare and submit to the Department, upon closure of the facility, a survey as-built which shows the location, types, and volume of waste deposited at the facility. A copy shall be made available to any purchaser or transferee at the time of property sale or transfer,

2.5.4.2 file the survey as-built of the tailings facility with the appropriate land records office within 60 days after the entire facility has been permanently closed, and submit proof of such recording to this Department,

2.5.4.3 install and maintain throughout the post-closure care period permanent markers, such as surveying benchmarks or GPS markers, from which the exact location of the closed facility and waste disposal pile can be determined.

2.5.4.4 record a notation on an instrument that is routinely examined on a title search of the property within 60 days of permanent closure notifying subsequent landowners:

2.5.4.4.1 the land has been used as a monofill,

2.5.4.4.2 the type of waste that has been buried on the property,

2.5.4.4.3 the geographic boundaries of the waste management areas, 2.5.4.4.4 details of any final cover, cap, or other structures or devices installed as a part of closure, and,

2.5.4.4.5 an engineered soil cover system has been placed over the waste and operations are carried out in a way that does not destroy or damage the performance or integrity of the cover system.

2.5.4.4.6 A detailed geographic location of any outfall pipe and diffuser if required.

2.5.5 The permittee shall conduct post-closure care for all parts of the facility. Post-closure care shall include:

2.5.5.1 post-closure monitoring as detailed in section 2.12 of this permit,

2.5.5.2 maintenance of the integrity and effectiveness of the final cover, slopes, vegetative cover, and drainage structures, including making repairs as necessary to correct the effects of settlement, subsidence, ponding, erosion, frost action, or degradation, and to prevent damage to the final cover by run-on and run-off and trees, and,

2.5.5.3 correction of any violation of permit conditions determined to be significant by the Department for the post-closure period.

2.6 MONITORING – GENERAL REQUIREMENTS

2.6.1 Monitoring requirements shall conform to the requirements of the Fresh Water Monitoring Program (FWMP) of the General Plan of Operations, and any Department approved updates to that program. In addition, the permittee shall adhere to 18 AAC 60.800 – 18 AAC 60.860 unless otherwise specified.

2.6.2 Test procedures for analysis of water samples and leachate samples shall conform to methods cited in the FWMP and 18 AAC 70.020(c), or as such regulations may be amended. To the extent the parameters, methods, and procedures of 18 AAC 70.020(c) differ from the FWMP, the permittee shall use the approved parameters, methods and procedures prescribed in the FWMP.

2.6.3 The Department may change monitoring requirements by permit modification or approval, in consultation with the permittee and the USFS, at the permittee's request, or in response to trends showing changes in the concentration of parameters being monitored,

2.6.4 Unless unforeseen circumstances occur, substitution of alternative methods of monitoring or analyses shall require prior written approval from the Department. When unforeseen circumstances require a change on site, those changes shall be reported to the Department within 30 days of those changes being made.

2.6.5 Problems found during visual monitoring, or an exceedance of a water quality standard during surface or groundwater monitoring at points of compliance, or a statistically significant change found in ground water monitoring results that suggests a problem shall be reported to the Department within 10 days of discovery. The report shall include a plan to correct the problem or state the actions taken to mitigate a problem needing immediate attention. The plan requires Departmental approval before implementation, except that advance approval is not required for actions taken to mitigate a problem needing immediate attention.

2.6.6 The Department may require a change in the sampling frequency, parameters or methods depending upon the results of analysis or change in operation.

2.6.7 If the permittee monitors any influent, effluent, receiving water, air or solid waste characteristic in addition to those identified in this permit, or monitors more frequently than required in this permit, the results of such monitoring shall be made available for inspection by the Commissioner or his/her representative at the project site, or other location proposed by the permittee and agreed upon by the Department. The permittee shall keep records for 5 years from the date of sample being taken for all monitoring and shall make records available for inspection to the Department upon request.

2.6.8 The general monitoring requirements of this section 2.6 are in addition to the specific monitoring requirements for the tailings and production rock, and the subject-specific monitoring requirements below.

2.7 MONITORING – VISUAL

The permittee shall:

2.7.1 conduct monthly visual checks of the facility when operations are in process, using an inspection checklist, in addition to any daily or weekly visual inspections made routinely as part of operation for which an inspection checklist is not required or used. During temporary closure visual inspections shall be conducted at least weekly in addition to the monthly inspection using a checklist. A person who is familiar with permit requirements shall conduct the checklist visual inspection, operations plan, closure and post-closure plan, corrective action plan, and the monitoring plan. Visual monitoring shall be conducted on routine facility operations, leachate collection and diversion systems, leachate pumping systems, the engineered cover and the facility perimeter. Structural changes or leakage noted during the inspections shall be documented. The Department may require more frequent monitoring if the conditions listed below exist. Visual monitoring shall include but may not be limited to the following:

2.7.1.1 signs of damage or potential damage to any component of the facility from settlement, ponding, leakage, thermal instability, frost action, erosion, slip failure, thawing of the waste, or operations that contribute to a problem,

2.7.1.2 violation of conditions of this Waste Disposal permit,

2.7.1.3 escape of waste or leachate,

2.7.1.4 unauthorized waste disposal,

2.7.1.5 slippage, erosion, cracks, or other damage to the visible portion of a cover system,

2.7.1.6 damage to the structural integrity of a monitoring device, containment or seepage structure, retaining wall, erosion control or diversion structure, and,

2.7.1.7 evidence of death or stress to fish, wildlife, or vegetation caused by the facility.

2.7.2 The permittee shall document total precipitation and average temperature since the last checklist inspection and shall comment on unusual or extreme weather events. Data shall be reported from stations at each site and shall be summarized in the annual report.

2.7.3 If any structural change in or damage to the facility, or any violation of permit condition is observed during the visual monitoring program, the permittee shall report to the Department within 10 days and take appropriate action to correct the violation or damage, prevent the escape of waste or leachate, and clean up any improper waste disposal.

2.7.4 The permittee shall summarize visual observations and submit these in the annual report.

2.8 MONITORING – GROUNDWATER

2.8.1 The permittee shall:

follow procedures outlined in the FWMP (GPO Appendix 1) and 18 AAC 60.820 – 18 AAC 60.860. The permittee shall provide the following as components in addition to those required by the FWMP unless otherwise provided in this permit:

2.8.1.1 sample and analyze ground water from a system of wells that yields water from the uppermost aquifer that represents the quality of:

2.8.1.1.1 background ground water that has not been affected by leachate from the facility, and,

2.8.1.1.2 where feasible, down-gradient ground water at points of compliance,

2.8.2 design, install, and decommission monitoring wells in accordance with the Department's Recommended Practice for Monitoring Well Design, Installation, and Decommissioning, April 1992 or as otherwise approved by the Department.

2.8.3 collect, analyze and report the results of sampling in accordance with the FWMP.

2.8.3.1 Provide in the annual report one or more plan documents showing the locations of waste pile internal (not for compliance purposes) monitoring routinely performed at each facility showing the locations for installed performance monitoring devices. In the annual report also provide updates to the plan documents, and of the FWMP's map depicting monitoring locations, showing any changes in monitoring locations. The plan document(s) and updates shall include or be accompanied by tables providing available information about the design and use of the sample points, including depth and sampling periods.

2.9 MONITORING - SURFACE WATER

2.9.1 The permittee shall sample and analyze all seeps of any contact water found during visual monitoring where the seeps migrate beyond seepage and run-off control structures. Also, the permittee shall collect a sample that is representative of background conditions if feasible. Surface water must be sampled at the place where the highest concentration of hazardous constituents migrating off the facility will be detected, so that interference from sources of pollution unrelated to the facility's solid waste management operations will be minimized. Surface water shall be sampled on a schedule that is approved by the Department. Samples shall be taken at least during seasons of high flow and low flow each year during the operational, closure, and post-closure care phases unless another schedule is approved or required by the Department. The results of this monitoring shall be summarized in the annual report.

2.9.2 Test procedures for the analysis of water samples shall conform to the parameters, methods and procedures in the FWMP and in 18 AAC 60.820-860.

2.10 MONITORING – LEACHATE

2.10.1 The permittee shall quarterly document the flow and analyze the leachate from the tailings disposal facility and production rock facility according to the "Tailings Internal Environmental Monitoring Program" in Appendix 3 and the "Production Rock Internal Environmental Monitoring Program" in Appendix 11, of the GPO. The samples shall be taken throughout the operational, closure and post-closure periods and the results of this monitoring shall be summarized in the annual report. See Table 1 for monitoring requirements.

2.11 MONITORING – BIOLOGICAL

2.11.1 Biological monitoring shall be conducted in accordance with the FWMP, Appendix 1 of the GPO.

2.11.2 Biological monitoring shall be conducted in July of each year as close in time as practical with the water chemistry monitoring required under Appendix 1, of the GPO using "suite P" parameters and methods. Should a significant increase occur in fish tissue of any of the parameters from "suite Q" that are not found in "suite P", then "suite Q" parameters and methods shall be monitored in water samples from that point forward.

2.12 MONITORING - POST-CLOSURE

2.12.1 Conduct visual monitoring semi-annually, in accordance with section 2.7 of this permit.

2.12.2 Conduct ground water monitoring semi-annually in accordance with section 2.8 of this permit. Samples shall be taken once during the dry season (May/June) and once during the rainy season (September/October).

2.12.3 Conduct surface water monitoring semi-annually in accordance with section 2.9 of this permit.

2.12.4 Conduct leachate water monitoring semi-annually in accordance with section 2.10 of this permit.

2.12.5 Conduct biological monitoring annually in accordance with section 2.11 of this permit.

2.12.6 Submit a post-closure care plan with updates to post-closure monitoring according to section 2.5.2.

2.12.7 Conduct an annual inspection for subsidence and movement within the pile by comparing the relative movement of the upper surface of the closed portion of the facility where subsidence and/or movement is expected to be the greatest over time utilizing either permanently installed survey markers or a GPS system. Observations shall be made consistently at the same general time each year or more often as the conditions deem necessary. The results of the inspection shall be reported to the Department with the annual report and shall detail the effect of any subsidence and/or surface movement on the integrity of the cover system, 2.12.8 Semi-annually monitor and document the infiltration/barrier, root zone layers and the establishment of growth and vegetation at the closed facilities in accordance with the approved final cover design. The analysis shall take place at least during the times of the year that represent high and low moisture precipitation. The results of these analyses shall include the following and be presented in the annual report:

2.12.8.1 Precipitation and temperature records for the week preceding on-site visual observations by means of remote weather stations at site 23 and Tailings,

2.12.8.2 measurement of soil suction and temperature by the use of a sufficient number of sensors, the number and location of which will be proposed by the permittee prior to installation of the cover for approval by the Department, for a period of time sufficient to determine the efficacy of the final cover system (semi-annually for the first five years, with subsequent monitoring needs determined from the data collected during this period),

2.12.8.3 measurement of cover infiltration rates by the use of a sufficient number of lysimeters at the base of the constructed cover system, the number and location of which will be proposed by the permittee prior to installation of the cover for approval by the Department, for a period of time sufficient to determine the efficacy of the final cover system (semi-annually for the first five years, with subsequent monitoring needs determined from the data collected during this period), and,

2.12.8.4 measurement of relative water content profiles by the use of a sufficient number of neutron probe access tubes, the number and location of which will be proposed by the permittee prior to installation of the cover for approval by the Department, for a period of time sufficient to determine the efficacy of the final cover system (semi-annually for the first five years, with subsequent monitoring needs determined from the data collected during this period).

2.12.9 Visual, ground water, surface water, leachate and biological monitoring shall be conducted at the frequencies shown in Table 1 of this permit. The permittee shall also record the rate of leachate discharged from the facilities at the frequency shown in Table 1.

2.12.10 If tailings underdrain water is discharged through the marine outfall, conduct marine sampling as specified in the EPA NPDES permit for the outfall.

2.12.11 The permittee shall include a summary of all post-closure monitoring results, records, and observations in the annual report.

2.12.12 At the end of the 30-year post-closure care period, the permittee shall conduct, in unison with a qualified independent third-party consultant, and agencies, an evaluation of whether the cover has met performance standards, and the facility can be considered retired in accordance with 18 AAC 60.490(c). This inspection shall include but not be limited to an analysis of surface water, ground water, leachates and a visual inspection of the cover. A final report shall be submitted to the Department that describes the site conditions and addresses appropriate management of trees on the cover to prevent the potential for blow-down damage. This report shall summarize the information collected during the post-closure care period.

2.12.13 Based upon the results of the 30-year post-closure care report, the agencies and the permittee will decide whether to continue post-closure care or treatment.

2.13 TABLE 1. SUMMARY OF MONITORING REQUIREMENTS

Operational Phase and Post-Closure Monitoring

Note: Monitoring under this permit is for the surface facilities and the area immediately surrounding them. There is no monitoring requirement for underground disposal areas.

The permittee shall perform the operational and post-closure phase monitoring described in the tables below, unless the permittee submits to the Department a modified table or tables describing operational monitoring and the Department approves the modified table or tables as providing for monitoring equally or more effective than that below.

Operational Phase – Tailings and Production Rock facilities

Item #	Comments	Type	WQ parameters	Frequency
2.6.1	GPO – FWMP (Appendix 1)	Various	Various	Varies
2.7	Visual	By checklist		Monthly
2.7	Visual	No checklist		Daily or weekly
2.7.2	Precipitation & temperature			Since last insp.
2.8.1	Groundwater	FWMP	Suite Q	Varies
2.9	Surface water	Seeps	Suite Q	As agreed
2.10		Leachate	Suite H	Quarterly
2.11	GPO FWMP App 1, Sec 6.7	Biological		Mid-late July

Operational Phase – Additional monitoring for just the Tailings facility

Item #	Comments	Type	Tests	Frequency
3.6.2	Tailings		Chemistry, NNP, paste pH	Four per quarter Annually
3.6.4	Proctor	Density		Quarterly
3.6.5	Phreatic water level	Piezometer		Quarterly

Operational Phase – Additional monitoring for just the Production Rock facility

Item #	Comments	Type	Tests	Frequency
4.1.1.2	Production rock		Chemistry, NNP, paste pH	Annually
4.1.1.4	Phreatic water level	Piezometer		Quarterly

Post-closure phase – Tailings and Production Rock facilities

Item #	Comments	Type	Tests	Frequency**
2.12.1		Visual		Semi-annual
2.12.2		Groundwater		Semi-annual
2.12.3		Surface water		Semi-annual
2.12.4		Leachate water		Semi-annual
2.12.5		Biological		Annual
2.12.6		NNP & paste pH		Every 5 years
2.12.7	Subsidence and movement	Survey marker inspection		Annual
2.12.8	Engineered cap			Semi-annual
2.12.8.1	Remote weather station	Precipitation & temperature		Week's weather prior to visit.
2.12.8.2	Soil	Suction & temperature		Semi-annual
2.12.8.3	Cap	Infiltration rate		Semi-annual
2.12.8.4	Cap	Water content		Semi-annual
2.12.10	NPDES	Marine		Per NPDES

** For the first five years post-closure, then as determined needed based upon the se monitoring results

*Suite Q from the FWMP - Conductivity,
pH, Temperature & Hardness
Sulfate
Total Alkalinity
Dissolved Arsenic, Barium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Silver & Zinc

*Suite H from the TIEMP - Conductivity,
pH, Temperature & Hardness
Sulfate
Total Alkalinity
Dissolved Arsenic, Cadmium, Copper, Lead, Mercury & Zinc
Common Ions: Dissolved Calcium, Magnesium, Sodium & Potassium
Nitrate plus Nitrite, Bicarbonate, Silica & Chloride

3 TAILINGS DISPOSAL FACILITY

The tailings facility will comprise a lease area of 123.3 acres and up to a final projected total tailings footprint area of 62.2 acres and total volume of 5.3 million cubic yards (9.6 million tons). The expansion of the tailings facility includes:

1. expansion of the existing Pit 5 quarry to provide construction materials for infrastructure development and construction within tailings disposal area and eventually, the placement of tailings;
2. construction of a new water management pond system;
3. installation of surface water and groundwater controls and diversions;
4. use of existing Containment Pond No. 6 for containment and storage of permited solid wastes;
5. development of a borrow and storage area for excavated reclamation materials (topsoil and organics); and,
6. development of borrow areas for infrastructure development and reclamation materials storage.

3.1 SEWAGE SOLIDS

Sewage solids may be disposed of to the tailings facility. They shall contain no less than 10% solids by weight and shall be treated with lime so that a pH of 12 is maintained in the solids after one hour of contact before disposal. Sewage solids shall be covered with at least 6 inches of cover material immediately after disposal.

3.2 CONSTRUCTION, OPERATION AND MANAGEMENT

The tailings facility shall be constructed, operated and managed according to the operations plan as cited in the July 23, 1999 Evaluation of the Tailings Pile, by Klohn-Crippen Engineering. Changes to this plan must be authorized by a permit modification or approval of the Department before the change can be implemented. The plan states the following as major elements:

3.2.1 tailings shall be placed in a cellular format and the pile is divided into a number of cells,

3.2.2 new tailings shall not be placed on uncompacted saturated tailings,

3.2.3 the tailings shall be placed in small areas, one or two adjacent cells at a time. The tailings shall be placed in one-foot lifts and immediately compacted with a smooth drum roller to a Standard Proctor Density of no less than 90%. If the tailings cannot be placed and compacted upon arrival at the tailings facility, they shall be stockpiled to minimize any additional moisture absorption during wet periods, or drying during warm periods. The tailings shall be handled such that specified placement densities are achieved,

3.2.4 the top surface of the cells shall be graded away from access roads to ensure surface water runs off, and compacted with a smooth drum roller to minimize infiltration from ruts or indentations,

3.2.5 placement shall then continue at another location/cell to allow time for any construction pore pressures, which may exist in the originally placed tailings, to dissipate, and,

3.2.6 construct with compacted outside side slopes that are no steeper than 3H:1V. Slopes during operation may be less than 3:1 if future operation or slope work is planned, or KGCMC receives approval for steeper slopes provided pile stability requirements are met.

3.3 2003 TAILINGS EXPANSION

The tailings area development shall follow the design and operational plans and objectives specified in the "Greens Creek Tailings Disposal" FEIS, dated November 2003, updated closure and post-closure plans specified under Section 2.4.1 of this permit, and other approved operating and engineering plans. Any changes to these plans which affect the design and performance shall be approved in writing by the Department. In addition, the following shall be implemented as major elements:

3.3.1 the facility shall be constructed according to the lease boundary and footprint approved by the U.S. Forest Service as presented in their ROD for "Greens Creek Tailings Disposal" FEIS, dated November 2003;

3.3.2 surface water interception and diversion structures shall be constructed to prevent run-on from flowing onto the active portion of the facility. The storm water control system must be capable of handling the peak discharge from a 25-year storm event;

3.3.3 ground water interception and diversion structures shall be designed and constructed having a permeability of no more than 1 x 10-6 cm/sec hydraulic conductivity;

3.3.4 expansion of the tailings pile shall be in accordance with an approved plan. The plan shall be submitted to the Department within 180 days of the USDA Forest Service issuing their approval for the lease boundary expansion and GPO amendment based upon their Record of Decision (ROD) for the "Greens Creek Tailings Disposal" FEIS, dated November 2003. The plan application material should specify the use of liners or other devices to prevent adverse impact to ground and surface water. The application material should specify underdrains, finger drains and french drains in a way which allows for tailings contact water to be effectively controlled;

3.3.5 underdrains shall be designed to minimize settling and clogging;

3.3.6 within the constraints of pile stability and safety, the facility shall be constructed in a manner that achieves maximum vertical expansion followed by closure according to Section 2.4 of this permit.

3.3.7 The permittee shall maintain the facility, correcting any erosion or settlement of the tailings that may impair water quality or otherwise threaten the environment.

3.4 WASTEWATER TREATMENT PROCESSES AND PIPING

3.4.1 The permittee shall notify the Department at least 60 days before any significant change in mill processes, which may affect the quality or characteristics of tailings outside of normal operating ranges. If such a change would significantly affect disposal operations, the permittee shall request approval from the Department for the change.

3.4.2 The permittee shall submit to the Department within 90 days after completing construction of a new process component or of a significant modification to an existing process component:

3.4.2.1 as-built drawings of process component(s) changes which would affect performance of that process component, as required by 18 AAC 72.600,

3.4.2.2 a summary of the quality control activities carried out during construction, and,

3.4.2.3 final operating plans that reflect modifications made during construction.

3.4.3 By January 29, 2006 provide sufficient storage to contain and control the 24-hour, 25-year storm event. Pond overflows shall be reported to the Department within 1 day of discovery and water samples immediately outside the pond dyke shall be taken according to the surface water monitoring protocols of the FWMP.

3.4.4 The permittee shall provide and maintain secondary containment for all process piping, chemical mix tanks, and facilities containing hazardous or toxic materials. Secondary containment is considered to be 110% of the largest tank within the containment. The permittee shall design and install secondary containment structures in a manner that ensures solid waste or leachate will not escape from the structures. Facilities to prevent such discharges shall be maintained in good working condition at all times by the permittee.

3.4.5 Secondary containment of all hazardous substances as defined at AS 46.03.826 (5) must be impermeable to those stored hazardous materials.

3.4.6 The permittee shall design all new process piping, chemical mix tanks, and facilities containing hazardous or toxic materials to allow for routine inspections for leaks.

3.4.7 The permittee shall maintain fuel handling and storage facilities in a manner intended to prevent the discharge of hazardous substances. A Spill Prevention Control and Countermeasure Plan (SPCC Plan) shall be in effect according to provisions of 40 CFR 112 for facilities storing 660 gallons of fuel in a single container above ground, 1320 gallons in the aggregate above ground, or 42,000 gallons below ground.

3.5 SPILL RESPONSE PLAN AND NOTIFICATION

3.5.1 The permittee shall notify the Department of a discharge of any hazardous substance at the facility in conformance with 18 AAC 75, Article 3.

3.6 MONITORING - TAILINGS FACILITY

3.6.1 Visually monitor the facility in accordance with section 2.7.

3.6.2 Analyze four samples of fresh tailings each quarter for the Net Neutralizing Potential and exposed tailings annually for paste pH in accordance with Appendix 3 Section 4 of the GPO.

3.6.3 Maintain an inventory of all tailings wastes and an estimate of all other wastes disposed at the tailings facility.

3.6.4 Conduct quarterly Proctor density tests of tailings waste disposed into the facility.

3.6.5 Conduct semi-annual monitoring of the phreatic water surface using all installed methods capable of producing reliable data on water levels within the pile. Annual reports shall include a graphical cross-sectional representation of the phreatic water level during the reporting period. The phreatic water level shall be drawn on a cross-section of the tailings pile such that the distance from the surface and base of the pile is shown.

3.6.6 Observe and report any damage to the piezometers and any other monitoring devices.

3.6.7 The permittee shall provide summary data in an annual report. If data indicates exceedence or a problem, then report the exceedence or problem within 10 days of knowledge of the exceedence or problem.

4 PRODUCTION ROCK DISPOSAL FACILITIES SITES 23 AND D

The Production Rock disposal facility comprises two disposal sites designated Site 23 and Site D. Site D, adjacent to Greens Creek, was the first disposal site, primarily containing materials from development of the mill site area. The total area of site D is 8 acres and the volume of materials deposited was 210,000 cu. yd. Site D is filled to capacity and no longer receives waste. Site 23 is located immediately upslope of Site D and is permitted by the USFS for an ultimate area of 11 acres and has an estimated total capacity of 1.2 million cubic yards. Between sites 23 and D runs the "B" road to the mine and mill, and beneath the road lies a curtain drain to divert subsurface flows beneath Site 23 from contact with Site D.

4.1 CONSTRUCTION, OPERATION, MANAGEMENT AND MONITORING

The facilities shall be constructed, managed, maintained and operated in accordance with Appendix 11 of the GPO and the permit application materials submitted to the Department September 7, 2000. Changes to this plan must be authorized by a permit modification or approval of this Department before the changes can be implemented.

4.1.1 Monitoring – Production Rock

4.1.1.1 Visually monitor the facility in accordance with section 2.7.

4.1.1.2 Analyze annually for the chemistry, net neutralizing potential and paste pH. The sampling schedule shall be in accordance with Appendix 11 of the GPO.

4.1.1.3 Inventory all production rock wastes at Sites 23/D, including the numerical classification. The annual report shall include a graphical cross-sectional representation of the various placement zones for waste classes at the site and the amount of waste placed during the reporting period.

4.1.1.4 If present, conduct semi-annual monitoring of the phreatic water surface using all installed methods capable of producing reliable data on water levels within the pile. Annual reports shall include a graphical cross-sectional representation of the phreatic water level during the reporting period. The phreatic water level shall be drawn on a cross-section of the production rock pile such that the distance from the surface and base of the pile is shown.

4.1.1.5 Observe and report any damage to the piezometers and any other monitoring device.

5 UNDERGROUND DISPOSAL OF WASTES

5.1 TYPES OF WASTE ALLOWED

5.1.1 Production rock and tailings are allowed at the underground facility

5.1.2 Up to five percent of the waste at the underground facility may be non-hazardous incidental wastes which may include the following:

5.1.2.1 tailings mixed with cement as required to provide stability for adjacent mine activities,

5.1.2.2 iron (drill steel, empty cans, etc.),

5.1.3 used ventilation tubing,

5.1.4 tires,

5.1.5 used filter press cloth,

5.1.6 empty plastic and glass containers and other incidental wastes such as non-hazardous domestic garbage,

5.1.7 empty triple rinsed chemical containers,

5.1.8 settled solids from sumps, ditches and degritting basins,

5.1.9 such other material as would otherwise be disposed of in a surface landfill without special handling, and

5.1.10 other wastes only if disposed with written approval of the land manager and the Department.

5.2 OPERATIONAL PHASE

5.2.1 The permittee shall maximize deposit into the underground workings of the mine tailings and production rock.

5.2.2 The permittee shall notify the Department of a discharge of any hazardous substance at the facility in compliance with 18 AAC 75, Article 3. Reportable spills include but are not limited to unplanned discharges of oils, solvents, glycol, acids, process chemicals, or other hazardous wastes as defined by 40 CFR 261 which would violate limitations in this permit. All spills must be cleaned up in accordance with an approved spill plan and to the satisfaction of the Department.

5.3 CLOSURE, POST-CLOSURE CARE AND MONITORING

5.3.1 At least 180 days prior to planned, permanent closure of the underground facility, the permittee shall submit closure and post-closure care plans to the Department for approval. The permittee is encouraged to submit the specific plan sooner than 180 days if possible. This plan shall include but not be limited to:

5.3.1.1 waste disposal locations and inventory,

5.3.1.2 procedures, methods, and a schedule for securing and maintaining closure of the facility,

5.3.1.3 control of surface and ground water drainage to and from the facility and the surrounding area.

6 REPORTING AND RECORDKEEPING

6.1 ADDRESSES AND PHONE NUMBERS

Provide all mailed reports and correspondence to:

Alaska Department of Environmental Conservation - AWQ
410 Willoughby Avenue, Suite 303
Juneau, AK 99801

Provide email copies to:
wqpermit@dec.state.ak.us

For reporting an incident by phone call either
ADEC Air & Water Quality @ 465-5300 or ADEC Solid Waste @ 465-5153

6.2 ITEMS TO BE SUBMITTED IN THE ANNUAL REPORT

6.2.1 Reports as detailed in Table 2.

6.2.2 A summary of the inspections and monitoring results set out in section 2.6 through section 2.13 of this permit. Copies of the laboratory reports with QA/QC information shall be made available for Departmental review on site.

6.2.3 A summary of any changes to the pertinent appendices of the General Plan of Operations (GPO) since the last submittal of any part of the GPO, or the last annual report. The permittee shall be prepared to discuss these changes to the GPO and whether such changes will require modification of this permit at the annual meeting with the department and any other agencies participating in that meeting.

6.2.4 Updates to the amount of financial assurance required for closure of the permitted waste disposal areas, including information on inflation, concurrent reclamation, expansion of the footprint, or other changes to the closure costs that have occurred since the last update. The financial assurance for the facility may be adjusted if the Department finds that the change is warranted, and the change amount is significant enough to justify the expenditure of the transaction costs of changing the financial assurance instrument. In the event of an increase, the new financial assurance instrument shall be due within 180 days of the Department’s response to the annual report.

6.2.5 The location and volume of the placed tailings, the volume of production rock placed at Site 23, test results from tests required under this permit, and a discussion of any water quality or solid waste disposal violations or unpermitted releases, or stability problems related to the surface tailings facility or Site 23.

6.2.6 An executive summary that presents a summary of the items of information specified in sections 6.2.1 to 6.2.5 of this permit.

6.3 PRESENTATION OF ANNUAL REPORT

6.3.1 The permittee shall provide an overview and explanatory presentation of the annual report approximately two weeks after hard copy and electronic versions have been submitted to the agencies. An annual meeting with the Department shall be held with other agencies also invited. This presentation shall be open to the public and the permittee should be prepared to answer questions related to the report.

6.4 MAINTENANCE OF RECORDS.

6.4.1 The permittee shall maintain a copy of the records listed in Table 3 in the facility's operating record. The records shall be made available to Department staff for review during facility inspections.

6.5 TABLE 2. REPORTING REQUIREMENTS.

SECTION	REPORTING ITEM	FREQUENCY/REPORTING PERIOD
2.3.2	Planned closure of 90 days or more	Notify Department at least 30 days prior to closure
2.3.2	Unanticipated closure of 90 days or more	Within 10 days after first day of temporary closure
2.3.3	Conceptual Temporary Closure Plan	Within 30 days of mill shutdown
2.3.4	Detailed Temporary Closure Plan	Within 60 days of mill shutdown
2.4.1	Detailed closure plan	180 days after the Forest Service approval of the GPO and lease changes based upon the Stage II Tailings Expansion EIS and ROD
2.4.2	Updated closure plan	At least 60 days prior to permit renewal
2.4.2	Updated closure plan if changes made during the preceding year	Annual report
2.4.4	Changes to closure plan	At least 30 days prior to closure or equipment removed

SECTION	REPORTING ITEM	FREQUENCY/REPORTING PERIOD
		or equipment removed
2.4.5	Updated reclamation & monitoring plan	Within 90 days of mill shutdown
2.5.2	Post-Closure Care Plan	At least 180 days prior to closure
2.5.4.1	Survey as-built	Upon closure of the facility
2.5.4.2	File survey with Lands records office	Within 60 days of closure
2.5.4.4	Record details on plat	Within 60 days of closure
2.7.2	Precipitation and temperature	Annual report
2.7.3	Structural change or damage	Within 10 days of inspection
2.8.3.1	Plans or updates to the waste pile internal monitoring locations	Annual report
2.8.3.1	Update of waste pile internal monitoring and FWMP monitoring locations	Annual report
2.9.1	Surface seeps outside control structures	Annual report
2.10.1	Leachate	Annual report
2.11.1	Biological monitoring	Annual report
2.12.7	Post -closure Subsidence and movement	Annual report
2.12.8	Engineered cap performance	Annual report
2.12.11	Post-closure monitoring results, records, observations	Annual report
2.12.10	NPDES marine sampling	As required by the NPDES permit
2.12.12	30-year post-closure care report	Submit
3.4.1	Notification of Significant Change in Mill Wastewater Treatment Processes	At least 60 days before the change is implemented
3.4.2	New or Modified Wastewater Treatment Process Components: As-Built Drawings, QC Activities, Final Operating Plans	Within 90 days after completion of construction
3.5.1	Hazardous substance discharge	As specified in 18 AAC 75
3.6.6	Summary data of tailings monitoring	Annual report

SECTION	REPORTING ITEM	FREQUENCY/REPORTING PERIOD
5.2.2	Hazardous substance discharge	As specified in 18 AAC 75
5.3.1	Closure and Post-closure plans	At least 180 days prior to closure
6.2.2	Summary of inspections and monitoring results	Annual report
6.2.3	Summary of changes to the pertinent appendices of the GPO	Annual report
6.2.5	Location & volume of placed tailings Volume of placed production rock Test results Discussion of WQ or SW violations Discussion of WQ or SW unpermitted releases Stability problems at either facility	Annual report
6.2.6	Executive summary of items 6.2.1 through 6.2.5	Annual report

6.6 TABLE 3. RECORDKEEPING REQUIREMENTS.

RECORD KEEPING REQUIREMENTS	REGULATION CITATION:
Permit application and permit	18 AAC 60.235
Inspection records, training procedures, and notification procedures	18 AAC 60.235
Any demonstration, certification, finding, monitoring, testing, or analytical data required by 18 AAC 60.800 to 18 AAC 60.860	18 AAC 60.235
The operational plan	18 AAC 60.235
Any permit or record required under the Clean Water Act as that Act applies to leachate and stormwater discharges	18 AAC 60.235
As-built drawings	18 AAC 60.235
The quantity of each type of waste disposed at the facility	18 AAC 70.020
Water monitoring records & any related corrective action records	18 AAC 60.810
Ash monitoring records	18 AAC 60.020
Visual inspections and Records	18 AAC 60.800
Piezometer records (phreatic surface , damage to piezometer)	18 AAC 70.020
Subsidence records & consideration of cover integrity (distance)	18 AAC 70.020
Water volume measurements (flows from underdrains)	18 AAC 70.020
Closure & post-closure plans & post-closure	18 AAC 60.210(b)(14) & 60.490

RECORD KEEPING REQUIREMENTS	REGULATION CITATION:
notation to instrument that is routinely examined during a title search	
Closure & post-closure monitoring	18 AAC 60.490(c)

7 CORRECTIVE ACTION REQUIREMENTS

The permittee shall:

7.1.1 If any structural change in, or damage to, a facility is found such that environmental damage is likely to occur, or any violation of a permit condition is observed during monitoring or an inspection, the permittee shall take appropriate action as soon as practical to correct the damage or violation, prevent the escape of waste or leachate, and clean up any improperly disposed wastes.

7.1.2 If a statistically significant change in water quality is detected at a point of compliance as a result of the surface water monitoring program based on the criteria established in 18 AAC 60.830(h) and in the FWMP, or if a water quality standard is exceeded at any surface water point of compliance or groundwater downgradient monitoring well, the permittee shall:

7.1.2.1 orally notify and consult with the Department within one working day,

7.1.2.2 submit to the Department documentation of the occurrence and a plan to determine the cause and/or source of the exceedence within 5 working days,

7.1.2.3 evaluate whether the water quality standards in 18 AAC 70 are threatened to be or are exceeded at the point of compliance,

7.1.2.4 determine if migration of waste or leachate from the facility is the cause of the change in water quality;

7.1.2.5 determine the extent of the waste or leachate migration contamination;

7.1.2.6 submit for Department approval, within 10 working days, a plan of corrective actions to prevent adverse environmental impacts and further exceedences of applicable water quality standards or permit limits, and,

7.1.2.7 implement the corrective action plan as approved by the Department.

7.1.3 If a significant change occurs within the tailings pile to the pH, dissolved metals levels, net neutralizing potential or seepage flows, the permittee shall submit to the Department within 30 days of the change being detected the results of any data or analyses showing the change. If the change is deleterious, then submit a proposal on how to mitigate the change or changes.

7.1.4 If the engineered barrier cover has visually observable damage of a type indicative of a threat to the integrity of the cover, or the cover does not operate as designed, the permittee shall submit to the Department within 30 days of the problem being noticed details of the problem and a proposal on how mitigate the problem.

7.1.5 If the vegetative cover does not perform as expected, or is harmed such that it is unable to function as required, the permittee shall submit to the Department within 30 days of the problem being noticed details of the problem and a proposal on how mitigate the problem.

8 FACILITY AUDIT AND POLLUTION PREVENTION STRATEGY

8.1 FACILITY AUDIT

8.1.1 Prior to the renewal of this permit every five years (expected in 2008), in coordination with a review of the General Plan of Operations, and prior to and in preparation for the termination of this permit, a facility audit shall be conducted at the expense of the permittee. The Department, in consultation with other agencies having land use management or regulatory authority over the facility and the permittee, shall mutually set the audit scope, and select a qualified auditor. The company will bear the burden of contract management during the audit process. To qualify, an auditor must:

8.1.1.1 Certify that no relationship exists through professional, financial, or personal reasons that could bias the auditor’s judgment or the audit results and that no self-serving interest in the outcome of the audit exists;

8.1.1.2 Demonstrate a commitment to professional and ethical standards generally accepted in the environmental auditing profession; and

8.1.1.3 Demonstrate a professional proficiency in the specific areas of hardrock mining, associated environmental issues, and current federal/state regulatory programs and climate, and an appropriate working knowledge and appreciation of management principles, quantitative methods, and computerized information systems.

8.1.2 The intent of the audits will be to determine if both the facility management and regulatory controls of the facility provide reasonable assurances that the facility and controls are functioning as intended. The scope of subsequent audits may be revised as mutually agreed upon prior to initiation of each audit, to address specific issues or objectives not previously identified in this permit.

Identification of such issues or objectives may be accomplished through a joint permittee/agency meeting prior to the audit.

8.1.3 The audit will be an objective, systematic, documented review of the conditions, operations, and practices related to permit requirements and facility management conducted under this permit. The audit shall evaluate:

8.1.3.1 the permittee's compliance with all federal, State and local permits and authorizations related to the permitted facility, and specific compliance with the conditions of this permit;

8.1.3.2 The permittee's compliance with internal environmental policies, plans, and procedures, and established environmental management systems and policies, are subject to updating, amendment, or revision upon mutual agreement of the parties;

8.1.3.3 the reliability and integrity of information relating to facility reporting and compliance;

8.1.3.4 the adequacy of the Department's permit and other agencies' oversight of the facility;

8.1.3.5 the condition of containment structures;

8.1.3.6 laboratories and sample analysis procedures;

8.1.3.7 the pollution prevention strategy in section 10.8 of this permit; and,

8.1.3.8 the adequacy of the closure and post-closure bonding, including the collection, treatment and long-term disposal of contact water.

8.1.4 The Department and permittee will use the audit results to assist in:

8.1.4.1 updating, renewing, or amending this permit,

8.1.4.2 updating policies, plans, and procedures,

8.1.4.3 determining compliance with this permit, and

8.1.4.4 determining the adequacy of the closure and post-closure bonding, including the collection, treatment and long-term disposal of contact water.

8.1.5 The facility audit may be a component of, or combined with, an audit required by other agencies' permits or approvals or agreements pertaining to the Greens Creek Mine.

9 FINANCIAL RESPONSIBILITY

Solid waste regulation 18 AAC 60.265 allows the Department to require proof of financial responsibility for closure of the facility and post-closure monitoring. Although closure of the facility, apart from incidental concurrent reclamation of portions of the facility, is not expected within the term of this permit, financial responsibility is required for all closure activities, as if performed by a third party, based on the assumption that full closure, for whatever reason, may occur during the term of the permit. The closure activities and financial responsibility for them shall be based on the requirements of the approved GPO, Appendix 14, Attachment A Detailed Reclamation Plan cost estimates dated November 15, 2001, any updates to this plan and any closure-related requirements of this permit that exceed the requirements of the Reclamation Plan. Updates to the amount of financial assurance required for closure and post-closure monitoring of the permitted waste disposal areas, including information on inflation, concurrent reclamation, expansion of the footprint, or other changes to the closure costs that have occurred since the last update, shall be performed as required in section 6.2.4 of this permit. The financial assurance required for the facility may be adjusted if the Department finds that the change is warranted, and the increase or decrease in costs is significant enough to justify the expenditure of the transaction costs of changing the financial assurance instrument. In the event of an increase, the new financial assurance instrument shall be due within 180 days of the Department's response to the annual report.

9.1 BOND

9.1.1 The permittee shall provide the Department with proof of financial responsibility for closure of the facility and post-closure maintenance and monitoring. This proof shall cover financial responsibility for closure of the facility as required by this permit, and for post-closure care and monitoring of the facility for no less than 30 years. Financial assurance for post-closure monitoring and maintenance of a marine outfall and diffuser is for 50 years.

9.1.2 As of the date of this permit, the amount of financial assurance acceptable to the Department is $26,238,518 which reflects reclamation, closure and monitoring for the entire mine site, including the disturbance anticipated from development of the Stage II Tailings expansion of up to 123.3 acres of the tailings disposal facility. The details regarding financial assurance are specified in the KGCMC General Plan of Operations, Appendix 14, Attachment A dated November 15, 2001 (Detailed Reclamation Plan Cost Estimates) as updated October 2003, and as updated annually according to the requirements in Section 6.2.4 of this permit. Terms for the release and distribution of funds are specified in the financial instruments and in the Memorandum of Understanding (MOU), dated May 14, 2001.

9.1.3 The total amount of $26,238,518 shall be be secured before any expansion of the surface tailings facility into undisturbed areas occurs.

9.1.4 Should the amount of work estimated to be completed for closure purposes change, as determined annually or at the time of the 5-year audit and permit renewal, or for any changes to post-closure requirements, then the amount of financial responsibility shall be adjusted accordingly. The new or supplemental financial assurance instrument shall be secured within 180 days of the Department's response to the annual report.

9.1.5 The cost for reclamation, closure and post-closure care of the facility shall include but not be limited to all costs for:

9.1.5.1.1 administrative overhead,

9.1.5.1.2 equipment mobilization, assuming all required equipment has to be brought to the site by a contractor,

9.1.5.1.3 the execution of tasks by contractors, including the cost of Davis-Bacon wages for contractor employees,

9.1.5.1.4 the cost of maintaining an abandoned site until and during final reclamation,

9.1.5.1.5 the long-term care and monitoring costs, and,

9.1.5.1.6 a contingency amount for unforeseen items.

9.1.6 The permittee shall comply with the Memorandum of Understanding (MOU) dated May 14, 2001, or any updates to this MOU, as agreed to by the Department and KGCMC.

9.1.7 The following requirements shall apply:

9.1.7.1 Where there are changes to the reclamation plan for the tailings facility and sites 23/D, the permittee will provide the Department with annual updates to the GPO Appendix 14, Attachment A, Detailed Reclamation Plan, and submit such updates with the annual report.

9.1.7.2 The permittee shall provide a complete update of the closure plan and Appendix 14, Attachment A Detailed Reclamation Plan including calculations suitable for determining whether adjustments for inflation are in order. This information shall be updated and submitted at each 5-year submittal of the audit, permit renewal application, or a significant change in the design or operation of the facility requiring amendment of this permit.

9.1.7.3 The proof of financial responsibility may be in the form of a trust fund, surety bond, letter of credit, insurance, or any other mechanism approved by the Department.

9.1.7.4 Any interest earned by the bond shall remain with the bond or other form of financial responsibility.

9.1.7.5 Approved proof of financial responsibility must remain in effect through the post-closure period for no less than 30 years, at a level determined by the Department to be necessary to ensure performance of obligations remaining after closure.

9.1.7.6 Partial release of the total financial responsibility amount, including accumulated interest, shall occur when closure has been satisfactorily achieved and the engineered cover system is shown to be operating as designed. The release of all amounts not required to ensure performance of post-closure maintenance, long-term water treatment/disposal and monitoring shall occur after both of the following: all site specific physical requirements of the Reclamation Plan have been met, and cover performance has been determined by the Department to be satisfactory.

9.1.7.7 Final release of the remaining bond amount, including interest, but excluding those costs for long-term maintenance and monitoring of any contact water disposal system shall not occur until the requirements for post-closure monitoring have been met and the engineered cover is shown to be operating as designed at the end of the 30 year post-closure period. Retention of the balance may be extended after this if the Department is not fully satisfied that full environmental protection exists at the end of the post-closure period.

9.1.7.8 No part of financial responsibility will be released until the Department certifies in writing that the requirements for partial or full release of the bond have been met.

9.1.7.9 Should another entity assume responsibility for permit compliance and/or post-closure monitoring, release of financial responsibility to KGCMC shall not occur until that other entity provides proof of financial assurance of the same amount to be released.

9.1.7.10 If the permittee is unable to continue acceptable proof of financial responsibility, or provide sufficient bonding determined by periodic updates, this permit will terminate automatically at that time, notwithstanding any other approvals to the contrary.

9.1.7.11 If the permittee fails to comply with the terms and conditions of this permit, as written, renewed, modified or amended, and if the Department concludes that such failure may prevent, inhibit or delay satisfactory closure or post-closure monitoring of the disposal facility, then, following notification and a reasonable time period for the permittee to respond to the

Department findings, the Department may exercise its rights under the approved mechanism for financial responsibility to access the funds and use them for appropriate closure and post-closure activities.

10 GENERAL PERMIT CONDITIONS

10.1 ACCESS AND INSPECTION.

10.1.1 The permittee shall allow the Commissioner or his/her representative access to the permitted facilities at reasonable times to conduct scheduled or unscheduled inspections or tests to determine compliance with this permit, state laws, and regulations.

10.1.2 Information access. Except where protected from disclosure by applicable State or Federal law, all records and reports submitted in accordance with the terms of this permit shall be available for public inspection at the State of Alaska Department of Environmental Conservation, Juneau, Alaska.

10.2 CIVIL AND CRIMINAL LIABILITY

10.2.1 Nothing in this permit shall relieve the permittee from any potential civil or criminal liability for noncompliance with the permit or with applicable law.

10.3 AVAILABILITY.

10.3.1 The permittee shall post or maintain a copy of this permit available to the public at the facility.

10.4 ADVERSE IMPACT.

10.4.1 The permittee shall take all necessary means to minimize any adverse impacts to the receiving waters or lands resulting from noncompliance with any limitation specified in this permit, including any additional monitoring needed to determine the nature and impact of the non-complying activity. The permittee shall cleanup and restore all areas adversely impacted by the noncompliance.

10.5 CULTURAL OR PALEONTOLOGICAL RESOURCES.

10.5.1 Should cultural or paleontological resources be discovered as a result of this activity, work which would disturb such resources is to be stopped, and the State Historic Preservation Office, Division of Parks and Outdoor Recreation, Department of Natural Resources (907-465-4563), is to be notified promptly.

10.6 APPLICATIONS FOR RENEWAL.

10.6.1 In accordance with 18 AAC 15.100 (d), applications for renewal or amendment of this permit must be made no later than 30 days before the expiration date of the permit or the planned effective date of the amendment.

10.6.2 This permit does not relieve the permittee from the duty to obtain any other necessary permits from the Department or from other local, state, or federal agencies, and to comply with the requirements contained in any such permits. All activities conducted and all plans implemented by the permittee pursuant to the terms of this permit shall comply with all applicable local, state, and federal laws and regulations.

10.7 TRANSFER OF OWNERSHIP

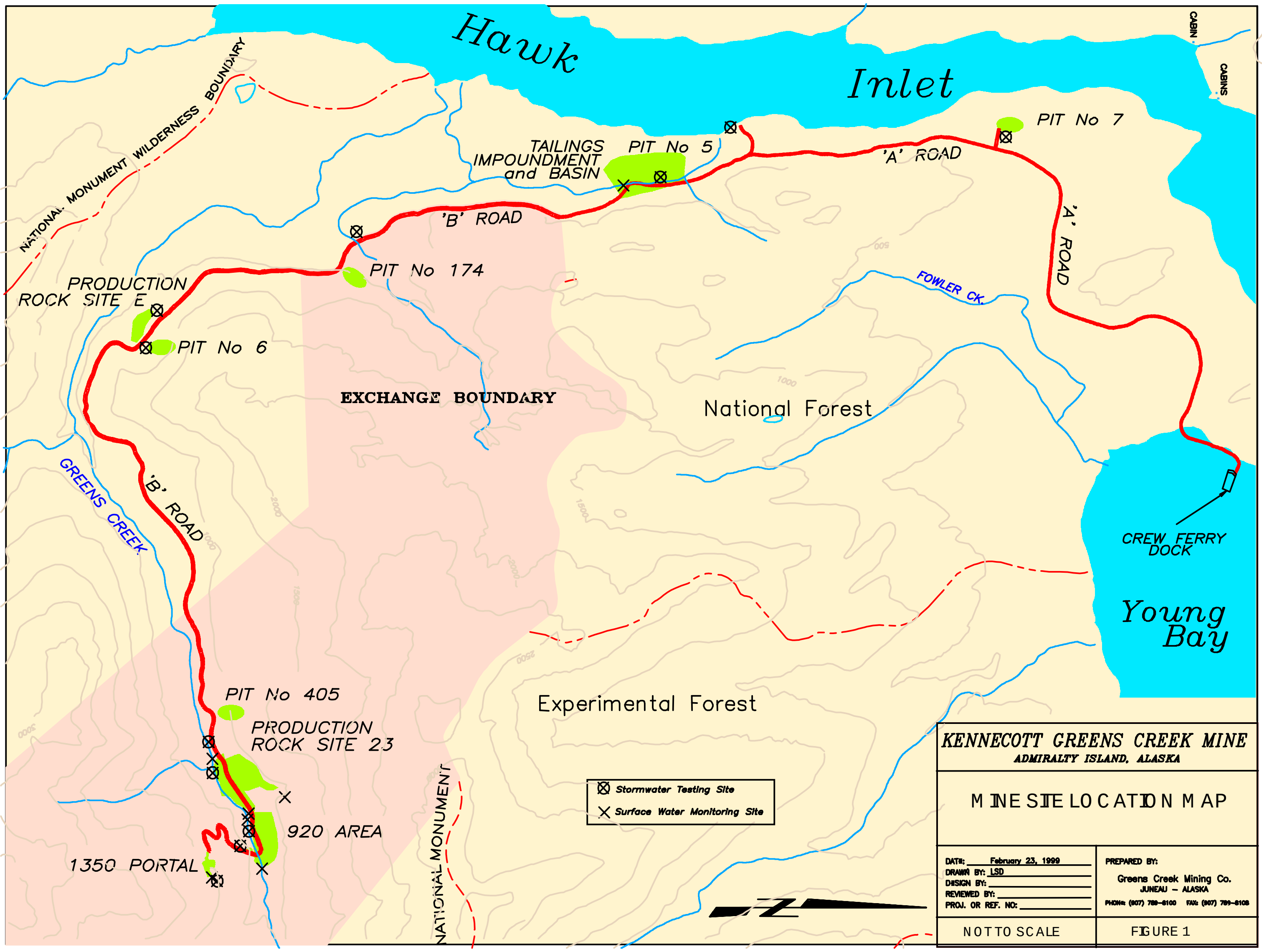
10.7.1 In the event of any change in control or ownership of the permitted facility, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Director of Air and Water Quality. The original permittee remains responsible for permit compliance unless and until the succeeding owner or controller agrees in writing to assume such responsibility, and the Department approves assignment of the permit. The Department will not unreasonably withhold such approval. However, the Department may require a reasonable period of post-closure observation of water quality before approving assignment of this permit to an organization contemplated by any Agreement for Funding Post-Reclamation Obligations entered into by the permittee and the Alaska Department of Natural Resources. As between the State and the permittee, no transfer of this permit shall relieve the permittee of any liability arising out of operations conducted prior to such transfer, regardless of whether such liability accrues before or after such transfer.

10.8 POLLUTION PREVENTION

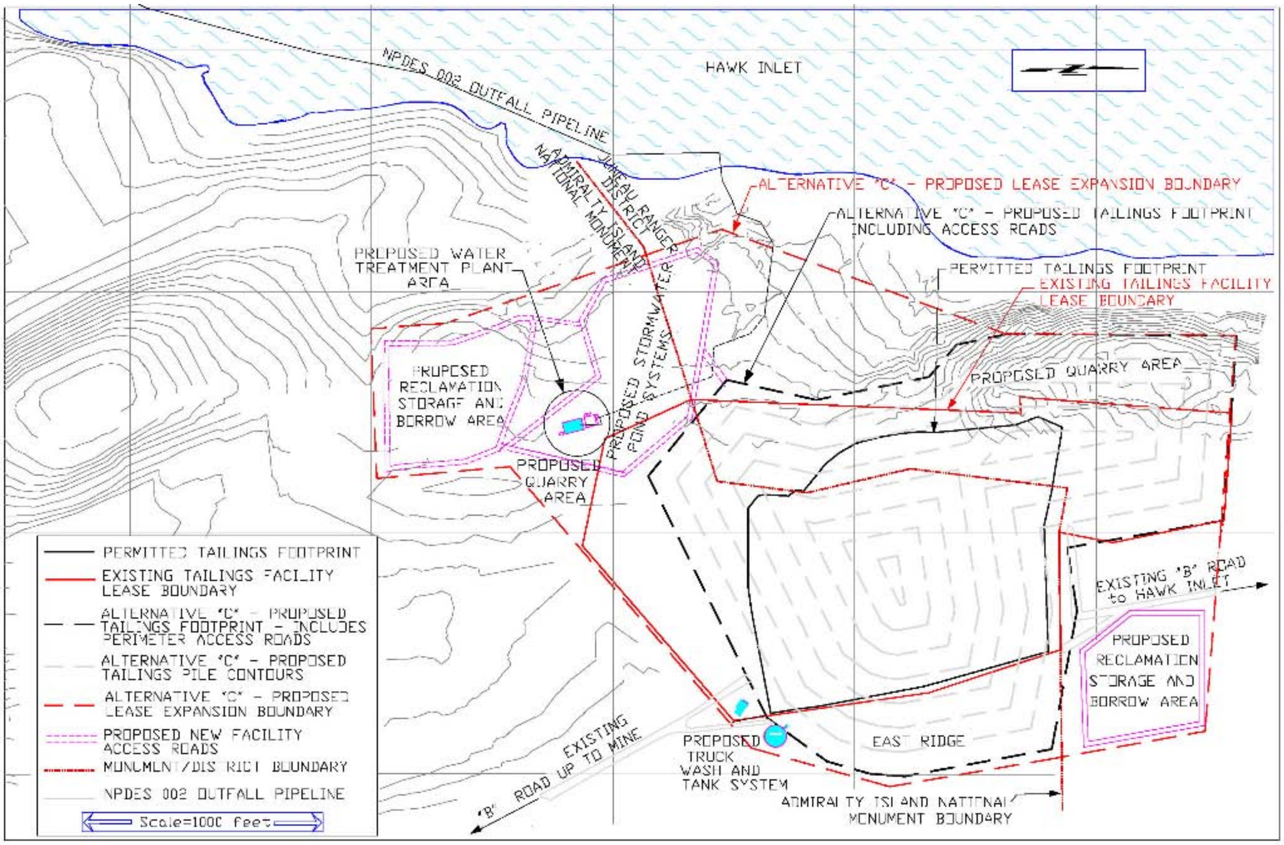
10.8.1 In order to prevent and minimize present and future pollution, when making management decisions that affect waste generation, the permittee shall consider the following order of priority options as outlined in AS 46.06.021: waste source reduction, recycling of waste, waste treatment, and waste disposal.

11 MAPS

11.1 LARGE SCALE MAP OF ALL MINE FACILITIES



11.2 MAP OF TAILINGS FACILITY



11.3 MAP OF PRODUCTION ROCK SITE NOTE:

12 GLOSSARY OF TERMS

FWMP	Fresh Water Monitoring Program
GPO	General Plan of Operations – comprised of a number of Appendices. The Waste Disposal Permit references Appendix 1, the Fresh Water Monitoring Program, Appendix 3, Tailings impoundment, Appendix 11, Production Rock Piles and Appendix 14, Reclamation Plan.
USE	Unsaturated Soils Engineering, Ltd.
SPLP	Synthetic Precipitate Leaching Procedure
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
ADOL	Alaska Department of Labor
CBJ	City & Borough of Juneau
COE	U.S. Army Corp of Engineers
ADCBD	Alaska Department of Community and Business Development
EPA	United States Environmental Protection Agency
SEACC	Southeast Alaska Conservation Council
USDA-OGC	United States Department of Agriculture Office of General Council
USFS/ANM	United States Forest Service Admiralty National Monument
USF&WS	United States Fish and Wildlife Service
KGCMC	Kennecott Greens Creek Mining Company
AAC	Alaska Administrative Code
SPCC	Spill Prevention Control and Countermeasures Plan
MOU	Memorandum of Understanding

Appendix E

Response to DEIS Comments, 2003

Appendix E

Contents – Comment Types

Tables

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Appendix E
Response to DEIS Comments

The Greens Creek Tailings Disposal DEIS was distributed on April 25, 2003. The comment period extended to June 30, 2003. Comments were solicited from the general public, state and federal agencies, tribes, municipal governments, and non-profit/governmental organizations during the comment period. All comments received during the comment period, whether written in letters, electronic mail or comments taken at the Draft EIS public meeting were read and categorized into the issues discussed below.

A total of 2447 commenters submitted written comment statements in response to the Draft EIS, of those 2416 were received via email in two separate form letters. See Form Letter A (FLA) and Form Letter B (FLB) in Appendix H. 1305 copies of FLA were received (one hard copy was received by mail); 55 letters contained additional comments, revisions, or commentary. 1112 copies of FLB were received and 26 of those contained additional comments, revisions, or commentary, one hard copy was also received by mail. Many commenters raised several issues, and each issue was considered individually. A breakdown by general commenting group is shown below.

Individual members of the public	2437
Non-government organizations	4
Businesses	3
Federal Agencies	3
Total	2447

Following an initial review of the comments and a general analysis of the issues, each letter, e-mail message, and form was assigned an alphabetic code based on the name of the individual(s) submitting the comments. Each individual comment in each statement was then assigned a sequential number. For example, Comment Number FLA-1 is the first comment in the form letter submitted by 1305 individuals.

Once the DEIS comments were delineated and numbered by issue (see Appendix F), general areas of concern were identified. Comments are classified under the following 14 issue topics:

1. Hydrology and Geochemistry
2. Acid Rock Drainage (ARD)
3. National Monument Values
4. Wetlands
5. Wildlife
6. Fish
7. Bioaccumulation
8. Oceanography
9. Socioeconomic
10. EIS Process

11. Reclamation Plan
12. Alternatives
13. Cumulative Impacts
14. Non-technical Comments

Table E-1, Index of DEIS Comments, lists commenter, organization affiliation, address by city and state, and lists the author code assigned for each commenter. Table E-2, Index of Responses to DEIS Comments, lists the comment and response number. These tables are listed alphabetically and in numerical order for ease in tracking comments and responses.

We received 2416 copies of form e-mails. These were divided between two similar form e-mails. As with all comments, we identified, numbered, and responded to the issues in Form Letter A and Form Letter B. Hard copies of each individual email form letter are part of the planning record and available for review at the Juneau Ranger District office.

Note: Several of the referenced Tables, Figures and Appendices in the DEIS have been re-named in the FEIS.

Table E-1. Index of Draft EIS Comments

Author	Organization	City, State	Author Code
Letters, e-mail messages, and comment forms			
Form Letter A	Individual		FLA
Form Letter B	Individual		FLB
Brian Beffort	Individual	Reno, NV	BB
Pamela Bergmann	U.S. Department of the Interior	Anchorage, AK	PB
Steve Borell	Alaska Miners Association	Anchorage, AK	SB
Shirley Campbell	Individual	Juneau, AK	SC
Ann Carpenter	Individual	Reno, NV	ANNC
David Chambers	Center for Science in Public Participation	Bozeman, MT	DC
Amy Crook	Center for Science in Public Participation	Bozeman, MT	AC
Jai Crapella	Individual	Juneau, AK	JC
Russell Dick	Sealaska Corporation	Juneau, AK	RD
Joe Gutkoski	Individual	Bozeman, MT	JG
Kat Hall	Southeast Alaska Conservation Council, Northern Alaska Environmental Center, and Earthjustice	Juneau, AK	KH
Mark and Michelle Kaelke	Bear Creek Outfitters	Juneau, AK	MK
Judith Leckrone Lee	U.S. Environmental Protection Agency	Seattle, WA	JLL
Joyce Levine	Individual	Juneau, AK	JL
Kamie Liston	Individual	Juneau, AK	KL
K.J. Metcalf	Friends of Admiralty Island	Juneau, AK	KM
Alan Monro	Individual	Juneau, AK	AM
Judith Maier	Individual	Juneau, AK	JM
Jenny Pursell	Individual	Juneau, AK	JP
William Oelklaus	Kennecott Greens Creek Mine	Juneau, AK	WO
Jim Rehfeldt	Individual	Juneau, AK	JR
Charles Rinehart	Individual	New Freedom, PA	CR
Robert Robertson	Individual	Juneau, AK	RR
Tina Scruggs	Individual	Escondid, CA	TS
Wesley Shaw	Individual	Skagway, AK	WS
Geoff Shester	Individual	Juneau, AK	GS
Kelly Tonsmeire	Individual	asdn@ptialaska.net	KT
Joyce Wood	National Marine Fisheries Service	Silver Spring, MD	JW
Ann Yates	Individual	Juneau, AK	AY
Madeline Yamate	Individual	Woodland, CA	MY
Tom Zimmer	Individual	Juneau, AK	AK

Table E-2 Index of Responses to DEIS Comments	
Comment Number	Cross Reference
FLA-1	**12.8**
FLA-2	**2.1**
FLA-3	**10.26**
FLA-4	**3.5**
FLB-1	**12.7**
FLB-2	**3.5**
FLB-3	**2.1**
FLB-4	**10.26**
FLB-5	**3.5**
BB-1	**12.7**
BB-2	**2.1**
BB-3	**10.26**
BB-4	**3.5**
PB-1	**2.2**
PB-2	**11.4**
PB-3	**10.25**
PB-4	**6.2**
PB-5	**5.9**
PB-6	**8.3**
PB-7	**7.2**
PB-8	**1.92**
PB-9	**1.98**
PB-10	**1.93**
PB-11	**1.94**
SB-1	**12.9**
SB-2	**12.10**
SB-3	**10.27**
SB-4	**10.28**
SB-5	**10.29**
SC-1	**2.1**
SC-2	**10.26**
ANNC-1	**12.7**
ANNC-2	**12.12**
ANNC-3	**11.6**
ANNC-4	**12.12**
DC-1	**9.6**
DC-2	**11.1**
DC-3	**1.72**
DC-4	**1.77**
DC-5	**1.95**
DC-6	**1.96**
DC-7	**1.73**

Table E-2 Index of Responses to DEIS Comments	
Comment Number	Cross Reference
AC-1	**1.75**
AC-2	**11.2**
AC-3	**1.76**
AC-4	**1.77**
AC-5	**1.78**
AC-6	**1.95**
AC-7	**1.79**
AC-8	**1.81**
AC-9	**1.82**
AC-10	**1.72**
JC-1	**12.7**
RD-1	**9.7**
RD-2	**12.12**
RD-3	**12.13**
RD-4	**12.14**
RD-5	**9.8**
JG-1	**12.7**
JG-2	**10.26**
JG-3	**10.26**
JG-4	**3.5**
JG-5	**2.1**
JG-6	**2.1**
KH-1	**12.7**
KH-2	**10.16**
KH-3	**2.1**
KH-4	**2.1**
KH-5	**2.1**
KH-6	**2.1**
KH-7	**10.7**
KH-8	**2.1**
KH-9	**2.1**
KH-10	**12.3**
KH-11	**12.5**
KH-12	**12.6**
KH-13	**13.5**
KH-14	**2.1**
KH-15	**1.70**
KH-16	**1.71**
KH-17	**1.71**
KH-18	**10.8**
KH-19	**10.12**
KH-20	**10.13**
KH-21	**10.14**

Table E-2 Index of Responses to DEIS Comments	
Comment Number	Cross Reference
KH-22	**3.2 3.3 3.4**
MK-1	**10.30**
MK-2	3.5
MK-3	**11.7**
JLL-1	**1.1**
JLL-2	**1.2**
JLL-3	**1.3**
JLL-4	**1.4**
JLL-5	**1.5**
JLL-6	**1.6**
JLL-7	**1.7**
JLL-8	**1.8**
JLL-9	**10.1**
JLL-10	**10.4**
JLL-11	**10.5**
JLL-12	**10.17**
JLL-13	**10.6**
JLL-14	**1.9**
JLL-15	**1.10**
JLL-16	**1.11**
JLL-17	**1.12**
JLL-18	**1.13**
JLL-19	**1.14**
JLL-20	**1.15**
JLL-21	**1.16**
JLL-22	**1.17**
JLL-23	**1.18**
JLL-24	**1.19**
JLL-25	**1.20**
JLL-26	**1.21**
JLL-27	**3.1**
JLL-28	**1.22**
JLL-29	**1.23**
JLL-30	**1.24**
JLL-31	**1.25**
JLL-32	**1.26**
JLL-33	**1.27**
JLL-34	**1.28**
JLL-35	**1.29**
JLL-36	**1.30**
JLL-37	**1.31**
JLL-38	**1.32**
JLL-39	**1.33**

Table E-2 Index of Responses to DEIS Comments

Comment Number	Cross Reference
JLL-40	**1.34**
JLL-41	**1.35**
JLL-42	**1.36**
JLL-43	**1.37**
JLL-44	**1.38**
JLL-45	**1.39**
JLL-46	**1.39**
JLL-47	**10.2**
JLL-48	**1.40**
JLL-49	**1.41**
JLL-50	**1.42**
JLL-51	**1.43**
JLL-52	**1.44**
JLL-53	**1.45**
JLL-54	**1.46**
JLL-55	**1.47**
JLL-56	**1.48**
JLL-57	**1.49**
JLL-58	**1.50 1.51**
JLL-59	**1.52**
JLL-60	**1.53**
JLL-61	**1.54**
JLL-62	**1.55**
JLL-63	**1.56**
JLL-64	**4.1**
JLL-65	**4.2**
JLL-66	**4.1**
JLL-67	**5.3**
JLL-68	**5.4**
JLL-69	**5.5**
JLL-70	**5.6**
JLL-71	**8.1**
JLL-72	**8.8**
JLL-73	**1.57**
JLL-74	**6.1**
JLL-75	**12.1**
JLL-76	**1.58**
JLL-77	**9.1**
JLL-78	**9.2**
JLL-79	**7.1**
JLL-80	**1.59**
JLL-81	**1.60**
JLL-82	**13.1**

Table E-2 Index of Responses to DEIS Comments

Comment Number	Cross Reference
JLL-83	**1.62**
JLL-84	**1.63**
JLL-85	**1.64**
JLL-86	**1.65**
JLL-87	**1.66**
JLL-88	**10.3**
JLL-89	**1.67**
JLL-90	**4.3**
JLL-91	**4.4**
JLL-92	**1.68**
JLL-93	**9.3**
JLL-94	**13.3**
JLL-95	**5.7**
JLL-96	**13.4**
JL-1	**2.1**
JL-2	**10.26**
JL-3	**10.26**
JL-4	**2.1**
JL-5	**2.1**
JL-6	**1.78**
JL-7	**1.70**
JL-8	**3.5**
KL-1	**12.7**
KL-2	**10.13**
KL-3	**9.4**
KL-4	**9.5**
KM-1	**3.5**
KM-2	**12.7**
KM-3	**12.7**
KM-4	**3.5 2.1**
KM-5	**3.4**
KM-6	**5.1**
KM-7	**3.5**
KM-8	**12.7**
AM-1	**2.1**
JM-1	**10.30**
JM-2	**10.26**
JP-1	**2.1**
JP-2	**10.26**
WO-1	**1.89**
WO-2	**11.8**
WO-3	**11.8**
WO-4	**1.99**

Table E-2 Index of Responses to DEIS Comments

Comment Number	Cross Reference
WO-5	**10.18**
WO-6	**10.19**
WO-7	**10.20**
WO-8	**10.21**
WO-9	**10.22**
WO-10	**10.23**
WO-11	**10.24**
WO-12	**1.99**
WO-13	**1.91**
WO-14	**4.5**
WO-15	**11.3**
WO-16	**5.8**
JR-1	**12.2**
JR-2	**10.26**
CR-1	**12.7**
CR-2	**2.1**
CR-3	**3.5**
RR-1	**2.1**
RR-2	**3.5**
RR-3	**9.7**
RR-4	**9.7**
TS-1	**12.7**
WS-1	**12.7**
GS-1	**12.7**
GS-2	**6.14**
GS-3	**9.4**
GS-4	**9.5**
KT-1	**12.7**
JW-1	**6.3**
JW-2	**6.4**
JW-3	**6.5**
JW-4	**6.6**
JW-5	**6.7**
JW-6	**6.8**
JW-7	**6.9**
JW-8	**12.11**
JW-9	**1.97**
JW-10	**8.2**
JW-11	**8.4**
JW-12	**8.5**
JW-13	**8.6**
JW-14	**8.7**
JW-15	**7.3**

Table E-2 Index of Responses to DEIS Comments

Comment Number	Cross Reference
JW-16	**1.95**
JW-17	**1.92**
JW-18	**1.98**
JW-19	**1.99**
JW-20	**6.10**
JW-21	**6.11**
JW-22	**6.15**
JW-23	**6.12**
JW-24	**6.13**
AY-1	**12.7**
AY-2	**10.26**
AY-3	**10.26**
MY-1	**12.7**
MY-2	**3.5**
TZ-1	10.31

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Chapter 1 Hydrology and Geochemistry

1.1 The draft EIS predicts that the preferred alternative would result in water quality that exceeds the Alaska Water Quality Criteria (AWQC) for sulfate at the point of compliance (i.e., the lease boundary). The final EIS should include design elements, including mitigation measures that ensure that the preferred alternative would meet applicable AWQC both during operations and after closure. As stated in the cover letter, it is our understanding that Kennecott Greens Creek Mining Company (KGCMC) intends to rely on the existing waste water treatment plant to assure compliance with AWQC and also intends to examine the use of passive wetland treatment systems as a potential means of effectively treating runoff and leachate from the tailings pile. These measures need to be described and incorporated into the action alternatives along with data that demonstrates that AWQC will be met for sulfate after treatment.

Note: Some comments use the acronym, AWQC (Alaska Water Quality Criteria). Technically there are differences between the criteria for a specified water use and the standards for that criterion. In the context these commenters use AWQC, however, it is synonymous with the use of AWQS in the FEIS and in responses to comments in this document.

Please see the detailed explanation of the stochastic water quality assessment model in Chapter 4, Section 4.5. Based on the data shown in the Water Quality Model tables for the different alternatives, (See Tables 4-2, 4-3, 4-4, and 4-5), and depending on which alternative is selected in the Record of Decision, the Forest Service will require a bond to cover maintenance and operation of the Water Treatment Plant and/or the Outfall 002 pipe.

Under all alternatives, during mine closure and post-closure periods, water would continue to be treated until effluent quality is such that these treatment processes are not required in order to meet discharge requirements. At that time and depending on actual effluent quality, KGCMC would discharge water using one of these discharge/compliance scenarios, in decreasing order of preference. Diagrams of these scenarios are shown in Figure 2-1.

(1) Discharge into nearby surface or groundwater (a) without dilution water from pile runoff and groundwater, or (b) with such dilution. This discharge would meet fresh water quality-based effluent limits;

(2) Discharge directly into Hawk Inlet. This discharge would meet marine water quality–based effluent limits with a potential dilution factor from a mixing zone; or

(3) Continue to discharge into Hawk Inlet through a submerged diffuser. The effluent would meet the more stringent of either marine AWQS with a mixing zone or technology based limits.

No matter which scenario is used, KGCMC will be required to insure that all discharged water will meet AWQS. Any of these discharge scenarios would be conducted under an NPDES permit. The FEIS has been clarified to show the predicted water quality compared to both fresh and marine AWQS. The discharge will be determined by KGCMC's ability to meet AWQS – with or without a mixing zone.

See also: FEIS clarification in Chapter 2, Section 2.2, Elements Common to All Alternatives.

See also: Response 1.4.

1.2 The draft EIS lacks predictions of water quality impacts associated with the preferred alternative for antimony, chromium, copper, lead, mercury, nickel, selenium, and silver (see p. 4-27). The preliminary draft EIS contained this information so it is apparently an oversight. The final EIS must include water quality predictions for antimony, chromium, copper, lead, mercury, nickel, selenium, and silver for Alternative C, the preferred alternative, and demonstrate attainment of AWQC for all parameters.

This was a printing error and has been corrected in the FEIS.

1.3 The draft EIS compares the water discharged from the tailings pile to freshwater AWQC for each alternative to determine exceedances but then compares the loading to the current permit which uses marine AWQC as its basis for calculations. Either the discharges from the pile are going to the freshwater environment surrounding the pile (making the comparison to marine water irrelevant) or they are going to the marine environment (making the freshwater standards irrelevant). It is very confusing to read that the discharge won't meet AWQC but when compared with the "allowable" loads, they were less than "some small" percent of those prescribed in the current permit. The final EIS should explain what set of criteria - marine or freshwater - is relevant to protect beneficial uses and then consistently use those standards for comparison purposes.

The FEIS has been edited to clarify the confusion between marine and freshwater quality criteria, and which criteria are used. Currently, the effluent that is discharged from the tailings pile is required to meet AWQS for marine discharge (with a mixing zone). Please refer to Chapter 4, Section 4.5 which discusses in detail the predicted water quality scenarios under each of the four alternatives considered in this analysis. The goal over time is to achieve tailings pile effluent discharge that will meet AWQS for freshwater compliance, discharging directly into surface or groundwater using freshwater quality-based effluent limits, however, currently KGCMC is required to meet marine water discharge AWQS.

See also: Response 1.1

1.4 The draft EIS rarely discusses using the existing water treatment plant, if needed, to ensure attainment of AWQC. Readers could question whether continued use of water treatment is actually proposed. Descriptions of the tailings pile in the alternatives chapter (Figure 2-6) indicate that the tailings pile would cover the location of the existing water treatment plant. Only Alternative B addresses this problem by relocating the treatment plant. This oversight could also raise questions in the readers' mind about whether the preferred alternative would include using water treatment if needed. The final EIS must explicitly and clearly describe water treatment for all alternatives in chapter two, identify the new location of the water treatment plant, describe the overall effect on water quality from proposed actions and mitigation measures (including water treatment), and demonstrate that the mine is sufficiently bonded to operate the water treatment plant for as long as necessary.

Under all alternatives, water will continue to be treated during operations, closure, and post-closure using effluent treatment processes until treatment is not needed in order to meet discharge requirements. In all action alternatives, the existing water treatment plant would have to be moved. The map for Alternative B, C and D has been clarified to show that the existing water treatment plant (shown on Alternative A map) will be relocated.   Several sections of the FEIS have been clarified to reflect this. Please see Chapter 2, Section 2.2, Elements Common to Alternatives, and Appendix C: KGCMC General Plan of Operations – Appendix 14.

The Forest Plan requires that the KGCMC be sufficiently bonded. See Section 1.6.1, Federal Government. Comments submitted on this EIS specific to the bonding issue, will be considered in the Forest Service review and approval of the bond for KGCMC. The bond will cover the time period necessary until the tailings effluent needs no treatment in order to meet AWQS. The bond is reviewed annually by the ADEC and the Forest Service, and once every 5 years by an outside consultant, to consider any changed environmental or technological circumstances.

The EIS uses a stochastic water quality assessment model to predict water quality from the tailings pile over time. Please see the detailed explanation in Chapter 4, Section 4.5. Based on the data shown in the Water Quality Model tables for the different alternatives, (See Tables 4-2, 4-3, 4-4, and 4-5), and depending on which alternative is selected, the Forest Service will require a bond to cover maintenance and operations of the Water Treatment Plant and/or the Outfall 002 pipe for as long as necessary, until effluent from the tailings pile no longer needs treatment in order to meet marine AWQS. This is the current compliance scenario, and the water needs treatment to be in compliance with the marine AWQS.

See also: Response 1.1.

1.5 The EIS indicates that the preferred alternative would employ an adaptive management approach for adding carbon to enhance immobilization of dissolved metals. This strongly contrasts with the specific direction in Alternative D for carbonate addition where the final EIS specifies the amount of carbonate needed to fully neutralize the tailings and prevent the onset of acid rock drainage (ARD). To ensure that the preferred alternative would successfully deal with the potential for ARD and metals mobilization, the final EIS should answer as many questions as possible related to the feasibility and effectiveness of carbon addition. For example, the final EIS should describe more specifically how amending the tailings with carbon leads to sulfate reduction, where such an approach has been used and with what success, describe potential sources of carbon, their respective methods of application, and provide a rough estimate of the amount of carbon that might be needed. This section should describe the types of sulfide reducing bacteria that occur in the pile and the potential for the proliferation of other bacteria that could deter or perhaps reverse the sulfate reduction process (e.g., Thiobacillus ferrooxidans).

Clarifications and modifications regarding the sulfate reduction have been made to the FEIS, Chapter 2, Sections 2.4 and 2.5. Requested explanation of sulfate reduction is found in the FEIS Appendix B, *Sulfate Reduction Monitoring Program Outline 2002*. Requested information on carbon sources, application, and amounts is found in the FEIS Appendix A, *Hydrology and Geochemistry of the Greens creek Tailings Facility 2003*.

1.6 The discussion about pyrite circuits is overly complex. The EIS should summarize and simplify the discussion with flowcharts and diagrams that explain the basic physical and chemical processes in a pyrite circuit, a chart summarizing the differences between the pyrite circuit alternatives, and a simple explanation of why the pyrite circuit alternative was not considered in detail.

The discussion of pyrite circuits in the FEIS has been simplified in Chapter 2, Section 2.6.3. The full discussion of the alternative development process has been added (see Appendix G).

1.7 The draft EIS states (Page 2-35, Section 2.3, Monitoring) that no new monitoring plan has been developed because the existing plan is functioning appropriately. The final EIS should strive to incorporate up-to-date monitoring data that correctly depict the impacts of the current facility. Freshwater Monitoring Plan monitoring data for 2001 were only recently released in a 2001 annual report and this release followed preparation of the draft EIS. The final FEIS would benefit from inclusion of an evaluation of those results and other monitoring data at least through 2002 or even early 2003. Including up-to-date data would better disclose current conditions, anticipate impacts related to expansion alternatives, and indicate any need for increased monitoring. With this comment in mind, it is noted that Section 3.8 on ground water quality summarizes information on the occurrence and interpretation of elevated sulfate conditions in what would appear to be virtually all downgradient ground-water directions from the tailings pile, including north, south, and west. Though the interpretations presented in the draft EIS (page 3-42) suggest only contaminant sources other than leakage from the tailings pile, up-to-date monitoring information could help eliminate alternative explanations and could indicate that areas should receive improved monitoring coverage to amply measure the water conditions or to answer still unanswered questions. The same need to have up-to-date monitoring information applies to surface water, particularly the Hawk Inlet Catchment as described on page 3-46 and 3-47 of the Draft EIS.

Prior to the publication of the DEIS, the EIS interdisciplinary team reviewed the KGCMC 2002 Annual Report (which was published after the DEIS) as well as additional 2003 data which has been furnished to the commenter. Pertinent data and updated water quality information has been analyzed and is included in the FEIS, Chapter 3, Section 3.8.

1.8 The Greens Creek Mine is an underground zinc/silver mine. The EIS should describe the potential impact of current historically low zinc prices on the continued operation and reclamation of the Mine. The EIS should also describe specific measures that would be taken in the event of a temporary suspension of operations to prevent oxidation of tailings, as is required by the ADEC solid waste permit. This is critical since the continual addition of fine-grained tailings to the pile helps to impede oxidation.

Estimated dollar amounts and discussion of the cost of implementing each alternative has been added to the alternatives discussion and comparisons in Chapters 2 and 4. During the project development stage there were 12 alternatives considered, and each had a cost estimate included. This is part of the planning record and is available upon request.

Section 2.2.5 has been renamed “Temporary Closure and Reclamation After Closure”. Information added to this section of the FEIS that further explains temporary suspension of operations. Should the mine temporarily close due to poor economic conditions, KGCMC would be required to follow the ADEC Water Management Permit terms for the temporary closure of the mine. These terms involve the installation of a cap for the pile, and continued water treatment as necessary to meet marine AWQS.

See also: Response 1.1 and 1.4.

1.9 Page 1-6 states that before the proposed expansion could begin, the existing reclamation plan would need to be updated to set performance criteria for achieving AWQC. The EIS should explain when and how performance criteria would be set.

The NPDES permit, which is written by the EPA and approved by the ADEC, specifies the AWQS for tailings pile effluent discharge. The commenter is correct is saying that the existing reclamation plan would need to be updated to set performance criteria for achieving compliance with the Alaska Water Quality

Standards (AWQS). Depending on which Alternative is selected in the Record of Decision, the new Reclamation Plan will specify when and how performance criteria will be set. No matter which alternative is selected, all effluent discharged from the tailings pile will have to meet the AWQS for marine discharge, at a minimum.

See also: Response 1.1, 1.4.

See also: Section 1.6.1 and 2.2.3 of the FEIS.

1.10 Page 1-8 describes the engineered cover or cap. This section should quantify the amount of water running off the cap and describe the extent that evapotranspiration and cap design are reducing the water flowing off the cap.

Cap runoff and evapotranspiration are discussed in Section 2.2.2 of the FEIS and Section 2.2.2 of Appendix A Hydrology and Geochemistry of the Greens Creek Tailings Facility**.**

1.11 Page 1-14 could also describe EPA's Section 309 and NEPA review responsibilities.

These descriptions have been added to Chapter 1, Section 1.6.1.

1.12 Page 1-15 states that discharges must meet all effluent limitations including technology standards for water quality. Technology-based effluent limitations and water quality-based effluent limitations are different and both must be met to satisfy the CWA.

The commenter is correct. Section 1.6.1 has been modified to read:

"Section 402 of the CWA establishes the National Pollutant Discharge Elimination System (NPDES) program. This program authorizes EPA to permit point source discharges of effluent, including process wastewater and storm water. Discharges must meet all effluent limitations, including water quality-based and technology-based limitations established under other CWA sections. The Applicant's NPDES permit expires in November of 2003, and issues concerning its modification will be addressed in greater depth as part of that process."

The EPA will reissue a NPDES permit that will address the specific water quality discharge requirements based on AWQS certified by the ADEC. These AWQS can and do change over time, just as technology changes and advances over time. These are two different ways the EPA sets the limitations that have to be met in a NPDES permit. For example, if technology for removing a certain material from a tailings pile discharge effluent were to become more advanced (and reasonably available to the industry), then the technology-based effluent limitations specified in the NPDES permit might change accordingly.

1.13 Page 1-16. Section 1.6.2 should be revised to reflect the current State structure.

Section 1.6.2 has been clarified to reflect the current State structure.

1.14 Page 2-1, Section 2.1, Issues and Alternatives Development. Under Water Quality, The draft EIS notes that the process of greatest concern is sulfide oxidation which can lead to the release of sulfate and heavy metals into water. The release of acidity should also be added to the list.

The discussion in Section 2.1 Water Quality has been clarified in the FEIS to read:

"The process of greatest concern is sulfide oxidation. As noted in the discussion of significant issues (Section 1.4), acidity is created through the process of sulfide oxidation. This process can lead to the release of sulfate and heavy metals into water. Carbonate minerals such as dolomite that are abundant in Greens Creek tailings neutralize the acidity, but the sulfate and some metals may remain soluble in water at elevated concentrations. "

1.15 Page 2-2 states that sulfate reduction helps to reduce the concentrations of critical metals, especially zinc. This sentence should explain how sulfate reduction helps to reduce the concentrations of critical metals.

Section 2.1 Water Quality has been modified to read:

"Within the tailings pile, sulfate reduction occurs when organic materials are present. Sulfate reduction helps to reduce the concentrations of critical metals. When sulfate is reduced by microorganisms, two by-products, sulfide and bicarbonate are produced. The sulfide ions tend to form insoluble compounds with certain metals such as zinc and nickel, thereby reducing their concentration. Additionally, the bicarbonate tends to increase pH, which can reduce solubility of other metals, especially zinc. As such, sulfate reduction is a beneficial process to be supported during the life of the mine and after closure."

1.16 Page 2-2 describes the no action alternative. The EIS should state how long the mine could operate until limits to the size of the tailings pile would force operations to cease.

Page S-10 of the Executive Summary) the FEIS states: "The "No Action" alternative would not modify the existing GPO nor permit expansion of the tailings disposal facility beyond its currently permitted size. The tailings lease area is 56 acres. The tailings footprint would expand from its current size of 23 acres to the currently permitted 29 acres.

KGCMC would continue its present method of generating whole tailings. The tailings would be placed without chemical or biological additives other than those currently allowed by the State of Alaska solid waste permit. Under the current permit the existing tailings facility has space for about 600,000 additional tons of tailings. Without a permitted expansion of the tailings pile, the mine would run out of room for surface disposal of tailings in roughly 2 years of tailings disposal at the current level of production."

This information is also included in Chapter 2, Section 2.4.1 Alternative A.

1.17 Page 2-5 states that 29 acres of the permitted 56 acres would be used for the tailings pile. This section should briefly state how the other 27 acres would be used.

The following sentence has been added to Chapter 2, Section 2.4: 'The remaining 27 acres would be used for related infrastructure such as water treatment facilities, storm water storage ponds, reclamation materials storage and access roads to the tailings pile'.

1.18 Page 2-11 states that Alternative B would entail continued treatment of tailings contact water during operation but does not describe or summarize the existing treatment system. The EIS should do this.

Section 2.2 has been clarified to describe the existing treatment system.

1.19 Page 2-11 should define what is meant by phreatic levels.

The definition of phreatic has been added to the glossary Chapter 5.

1.20 Page 2-12 states that Alternative C would utilize the post-closure construction of an engineered soil cover on the pile to minimize infiltration of oxygen and water into the pile. The EIS should describe the type of soil proposed to be used, the effectiveness of the soil in minimizing oxygen and water, the availability of this soil, and the cost of the cap (to address economic feasibility and reclamation concerns).

All alternatives, including the No Action Alternative, depend on the use of an identical 4 layer engineered cover. Section 2.2.5 describes the cap, the type of rock and soil to be used, and the availability of the soil. Language has been added to describe the availability of drain rock and the effectiveness the cap. The unit cost of cap construction would be the same under all alternatives. Information about cover performance has also been added to the end of Section 2.2.5.

Multiple layer caps are used to exclude oxygen and water in mines throughout the world. Covers similar to the engineered cover proposed at Greens Creek have been designed and constructed by Dr. Ward Wilson at numerous mine sites in British Columbia, Saskatchewan, and in subtropical regions of Australia. The design and performance of this cap is discussed in *Final Report – Waste Rock Cover Design, Kennecott Greens Creek Mining Company*, prepared by

Unsaturated Soils Engineering Ltd., December, 1998 and is evaluated in *Cover System Performance at the Greens Creek Mine*, prepared by O'Kane Consultants, Inc. December 2001. Both documents are included in the planning record.

1.21 Page 2-12 states that this alternative aims for long-term chemical stability of the tailings through a continuous addition of carbon. Ideally, the EIS should describe how carbon would be transported from the Cannery, the extent of the carbon supply, the amount added, and the longevity of the carbon in the pile. However, the EIS states that results from a sulfate reduction monitoring plan (SRMP) would determine the amount of carbon used. The EIS should state at least conceptually how carbon could be injected into the pile.

Section 2.4.1, Alternative C has been modified with additional information in the second paragraph under "Water Quality".

1.22 Page 2-15. Figure 2-4 shows that the tailings footprint covers the existing water treatment plant but the list on this page does not indicate that relocating this plant is part of the plan. What happens to it?

Figure 2-4 has been re-named Figure 2-6, Alternative C – Existing Tailings Facility Lease Area, Present, and Projected Footprints of Tailings Placement in the FEIS. Figure 2-5 has been re-numbered Figure 2-7, Alternative C – Monument Values Changes to Proposed Lease Area in the FEIS. Text in Section 2.4 has been edited to reflect the placement of the Water Treatment Plant.

1.23 Page 2-19 identifies one element of Alternative C as the construction of a new water management pond system. The EIS should describe the system to a greater extent including if ponds are lined or unlined.

Section 2.2.1 has been clarified to describe the existing water treatment system.

1.24 Page 2-19 states that it is anticipated that additional carbon from an external source will be required to assure long-term sulfate reduction and chemical stability of the tailings disposal facility. The EIS should identify the potential types and location(s) of the external source of carbon, identify how much could potentially be needed, and the possible range of associated costs.

Section 2.4.3 Alternative C - East Ridge Expansion, has been modified with additional information to discuss the SRMP, which will determine these questions regarding carbon addition.

1.25 Page 2-19 states that the SRMP would determine the best form of supplemental carbon addition, the required amount, and the best method of application. To the extent possible, this information should be in the EIS. For example, the EIS should identify the best supplemental carbon addition and its application based on sample testing and available carbon sources and predict a range of possible quantities based on chemical analysis.

Section 2.4.3 Alternative C - East Ridge Expansion, has been modified with additional information to discuss the SRMP. The function of the SRMP is to determine these questions regarding carbon addition.

1.26 Page 2-19 states that post-closure water quality meets applicable effluent limits in the Kennecott NPDES permit. The current permit, however, contains effluent limitations applicable to a discharge to marine waters, not fresh waters. This is a source of confusion.

Chapter 2, Section 2.2 has been clarified to describe how KGCMC is required to meet AWQS. Also, see Response 1.1.

1.27 Page 2-20 states that about 2 million tons or 1 1/2 million cubic yards of limestone would be needed to sufficiently neutralize the tailings. The EIS should explain why it can specify quantities for limestone addition but not for carbon addition - the preferred approach for avoiding metals mobilization.

Section 2.4.4 has been clarified by adding a new last sentence to the second paragraph to read: "About 2 million tons, or 1½ million cubic yards, of limestone would be needed to sufficiently neutralize the tailings. The addition of carbonate to buffer acidity has been used for a long time and the amounts of limestone needed to provide a given amount of buffering capacity is well known."

Quantities of carbon addition are listed in Appendix A. This information been incorporated into several sections of Chapter 2. Additional information has been added to Section 2.4.3 in the second paragraph under "Water Quality".

1.28 Page 2-20 states that tailings placement and pile height would be the same as Alternatives B and C. The first paragraph of this section, Figure 2-6 and Table 2-1, all say that the tailings placement area increases. Please reconcile these different statements.

The sentence in question has been clarified to read: Pile height and the method of tailings placement would be the same as Alternatives B and C. The height of the pile for all action Alternatives is the same. See Section 2.4.4 of the FEIS.

1.29 Page 2-25. Section 2.2.1, Figure 2-7 shows the relocated treatment plant for Alternative B but relocation of this plant is not shown on any of the other figures for other alternatives even though the area where it is now located is proposed to be covered with tailings.

Figure 2-4 has been re-named Figure 2-6, Alternative C – Existing Tailings Facility Lease Area, Present, and Projected Footprints of Tailings Placement in the FEIS. Figure 2-5 has been re-numbered Figure 2-7, Alternative C – Monument Values Changes to Proposed Lease Area in the FEIS. Text in Section 2.4 has been edited to reflect the placement of the Water Treatment Plant.

1.30 Page 2-27 discusses cap design as a method to protect surface water. The final EIS should predict precipitation uptake through evapotranspiration. It should also predict how much precipitation would infiltrate through the cap following vegetation.

Cap runoff and evapotranspiration are discussed in Section 2.2.2 of the FEIS and Section 2.2.2 of Appendix A Hydrology and Geochemistry of the Greens Creek Tailings Facility**.**

1.31 Page 2-27 states that drainage water will continue to be captured through the drain system, flow into the wet-wells, and subsequently be transferred to the water treatment plant. The EIS should state if drainage systems would be maintained after mine closure and if money is set aside to ensure that such maintenance occurs.

The drain system is integral to the tailings pile, and actually located under the tailings. There is no direct access to the drains once they are covered with tailings, so maintenance is not possible without removing the cap and tailings that cover the drains. The materials planned for use in the drains are designed to have hydraulic conductivity rates at least 2 orders of magnitude higher than the liner system to facilitate drainage to the perimeter of the pile. Catastrophic failure of the drains is highly unlikely.

1.32 Page 2-28 describes the cap layers. The EIS should state if material is readily available to construct each layer of the cap.

All alternatives, including the No Action Alternative depend on the use of an identical 4 layer engineered cover. Section 2.2.5 describes the cap, the type of soil to be used, and the availability of the soil. Language has been added to describe the availability of drain rock and the effectiveness and cost of the cap. Information about cover performance and consequences of failure has been added to the end of Section 2.2.5.

1.33 Page 2-31. Define what are “-3" and “-2" materials.

The language in question in Table 2-3 was: “-3" to +1" clean drain rock”. This has been changed to: “Clean drain rock less than 3 inches and greater than 1 inch in diameter.”
The second phrase in question read: “-2” material”. This has been changed to:

“Rock less than 2 inches in diameter”, see Section 2.2.3.

1.34 Page 2-32 states that the company will identify sites that exhibit an existing ability to maintain enough water year-round for effective reestablishment of a wetlands environment. The EIS should contain this information.

That language in Chapter 2, Section 2.2.5 has been modified to read: “For this undertaking, KGCMC will identify sites that exhibit an existing ability to maintain enough water year-round for effective re-establishment of a wetlands environment. These sites would be located within the lease boundary southwest of the pile (See Figure 4-9). Site selection will be subject to approval by COE.”

1.35 Section 2.3 states that the company continually analyzes water quality. Is monitoring happening continually (i.e., indefinitely in time without interruption) or frequently? The EIS should explicitly state how often monitoring occurs happens (e.g., the company analyzes water quality weekly, monthly, etc.).

Section 2.2.3 has been modified to read:
“Routine water quality monitoring is required in the GPO and DEC Waste Management Permit. Under this plan, KGCMC analyzes water quality samples from several wells upgradient and downgradient from the tailings pile. No new monitoring plan has been developed at this time because the existing plan is functioning appropriately within the existing tailings lease boundaries. If Alternative B, C, or D is selected and approved in the ROD, modifications to the existing plan would be required to account for the change in the tailings lease boundary.”
See Appendix C, KGCMC. 2000. GPO Appendix 14, for water quality monitoring schedules.

1.36 Section 2.4.1 See comments about AWQC in general comments. Moreover, it is very confusing to read that the discharge would not meet AWQC but when compared with the “allowable” loads, they were less than (some small percent) those prescribed in the current permit. The final EIS should explain what set of standards is relevant to protect beneficial uses and then consistently use those standards for comparison purposes.

Chapter 2, Section 2.2 has been clarified to fully explain the hierarchy of discharge/compliance scenarios.
“During mine closure and post-closure periods, water would continue to be treated until effluent quality is such that these treatment processes are not required in order to meet discharge requirements. At that time and depending on actual effluent quality, KGCMC would discharge water using one of these discharge/compliance scenarios, in decreasing order of preference. Diagrams of these scenarios are shown in Figure 2-1.

(1) Discharge into nearby surface or groundwater (a) without dilution water from pile runoff and groundwater, or (b) with such dilution. This discharge would meet fresh water quality-based effluent limits;
(2) Discharge directly into Hawk Inlet. This discharge would meet marine water quality–based effluent limits with a potential dilution factor from a mixing zone; or
(3) Continue to discharge into Hawk Inlet through a submerged diffuser. The effluent would meet the more stringent of either marine AWQS with a mixing zone or technology based limits."

1.37 Pages 2-33 - 2-35 discuss water quality. It is difficult to understand the effects of different alternatives on water quality, especially compliance with AWQC, due to ambiguities about whether or when treatment occurs, marine discharge versus freshwater discharge, and the location of the point of compliance.

See response 1.36 above.

1.38 Pages 2-38 - 2-50 discusses pyrite circuit scenarios. This section is overly complicated to the extent that it precludes understanding by non-technical readers. The EIS should include flowcharts and diagrams that explain the basic processes of a pyrite circuit and what happens chemically and a chart summarizing the differences between the pyrite circuit alternatives.

The discussion of pyrite circuits in the FEIS has been simplified (see Section 2.6.3), and the full discussion of the alternative development process has been added (see Appendix G.

1.39 Page 3-1 states that the Greens Creek Mine is an underground zinc/silver mine. The EIS should describe the potential impact of current historically low zinc prices on the continued operation and reclamation of the Mine. The EIS should also describe specific measures that would be taken in the event of a temporary shutdown to prevent oxidation of tailings, as is required by the ADEC solid waste permit.

Section 2.2.5 has been renamed "Temporary Closure and Reclamation After Closure" and information added to the FEIS that further explains temporary suspension of operations.

1.40 Page 3-4. Recommend that Table 3-1 also include annual precipitation.

Table 3-1 has been expanded to include annual precipitation.

1.41 Page 3-4. The title of Table 3-1 states that it contains the data from 1994 - 2000 yet the table only shows 1997 - 2000 data. The final EIS should include data from 1994-1997 or change the title, and, if possible, include more recent data.

The title of Table 3-1 has been changed to reflect 1997 - 2000 data.

1.42 Page 3-7 states that the project site area has been designated as having attained air quality standards, or as being unclassifiable for all criteria pollutants. The final EIS should define "unclassifiable" for those readers unfamiliar with the Clean Air Act.

Chapter 3, Section 3.4 has been rewritten and the term "unclassifiable" has been removed.

1.43 Page 3-15 should read, "Turbidity averaged 0.556 Nephelometric Turbidity Units."

This change has been made.

1.44 Page 3-15 should explain why lead concentrations in Hawk Inlet and outside the sill vary, with location, from below detection limits to near acute levels.

Descriptions of long-term monitoring studies in 3.6 were expanded to include methods, timeframe, frequency and results of sampling sediments, tissue, and water. This section was moved into Section 3.13, Marine and Aquatic Ecosystem. Data tables summarizing results from these studies were added.

1.45 Page 3-7 should state if the tripling of lead in polychaete worm tissue is attributable to mine activities.

See response 1.44.

1.46 Page 3-17 should estimate the percentage of argillites and phyllites in the ore rock and the overall buffering capacity these geologic layers would provide.

The text refers to the characteristics of bedrock in the vicinity of the tailings. The discussion of the geology of ore zones was removed because it is not pertinent to the geology of the tailings area. The first paragraph in Section 3.7.1 has been `revised to read:

"The rocks and sediments found in the project area were formed over an extended period of geologic time. The bedrock consists of structurally complex Paleozoic age rocks that have been metamorphosed, folded and faulted. The primary rock types include quartz schist and carbon rich phyllite, each of which contains traces of pyrite."

1.47 Page 3-18 discusses treated water discharging into Hawk Inlet. The EIS should explain how water is currently treated.

Chapter 2, Section 2.2 has been clarified to fully explain the hierarchy of discharge/compliance scenarios and diagrams of each scenario have been added. The three scenarios are:

(1) Discharge into nearby surface or groundwater (a) without dilution water from pile runoff and groundwater, or (b) with such dilution. This discharge would meet fresh water quality-based effluent limits;
(2) Discharge directly into Hawk Inlet. This discharge would meet marine water quality–based effluent limits with a potential dilution factor from a mixing zone; or
(3) Continue to discharge into Hawk Inlet through a submerged diffuser. The effluent would meet the more stringent of either marine AWQS with a mixing zone or technology based limits.

Section 2.2.1 has been clarified to describe the existing water treatment system.

1.48 Page 3-23 should explain or define "quiet water marine".

This sentence in Chapter 3, Section 3.7.7 was rewritten to read: The till also contains layers of silt or clay that suggest quiet marine water deposition or wetland deposition intermittent with till deposition.

1.49 Page 3-31. The EIS should explain why a map of Alternative B is in the affected environment chapter.

This map shows the generalized ground water flow patterns that apply to all alternatives; its legend has been clarified.

1.50 General. Including the applicable water quality standard on charts discussing water quality would be extremely useful to reviewers to understand unacceptable pollution levels.

AWQS for most constituents of concern at the site (i.e., metals) are hardness dependent. Therefore, a specific standard is tied to a specific water quality sample. It is too cumbersome to list an individual AWQS for every sample listed in the FEIS. All pertinent water quality data is also available in the planning record.

1.51 Page 3-42 should state when the source of the sulfate in the Pit 5 area will be confirmed by excavating test pits and conducting additional geochemical and water quality analyses.

Section 3.8.1 (last paragraph) was clarified to read:
The findings of this evaluation indicate that the higher sulfate concentrations in the groundwater on the north side is likely due to the disturbed pyritic rock in the Pit 5 quarry area. The bedrock knob in the northwest corner of the tailings facility may also contribute. Confirmation of the source of the sulfate in the Pit 5 area will be made by continuing the water quality monitoring program described in KGCMC, 2003.

1.52 Page 3-47 should explain why the lower pH caused by the old access road constructed of rock containing pyrite is not indicative of the reaction that may be occurring in the tailings.

Section 3.8.2 has been clarified to explain why the lower pH caused by the old access road constructed of rock containing pyrite is not indicative of the reaction that may be occurring in the tailings.

1.53 Page 3-49 states that Vos estimated that acidification would not occur for more than 10.9 years, which would provide ample time for application of site closure technologies (e.g., the cover) to mitigate the ARD risk. The EIS should clarify how there would be "ample time" if mining is to occur for an additional 22 years before placing the cover on the tailings pile.

Chapter 3, Section 3.8.5 of the FEIS describes the testing that was conducted on siliceous waste rock. The subsequent paragraphs estimates a 25 to 50 year lag time before potential acidification of the tailings.

1.54 Page 3-50, Section 3.8, Water Quality. The DEIS uses paste pH measurements of tailings (shown in Figure 3-14) to support the concept that the tailings will neither acidify during operations nor for an indefinite period after closure. The same data are used in Appendix B (Michael Baker, Inc, 2003, pages 25-26) to conclude that the tailings have maintained an alkaline pH throughout the operation of the facility. However, these data may be somewhat misleading in that a check on the source of the most recent paste pH values shown in Figure 3-14, those from 1999, are listed in the Shepherd Miller, Inc (2000) reference as rinse pH rather than paste pH values. The paste pH values for the 1999 tailings samples, as listed in the Shepherd Miller reference, are all lower in pH than the rinse pH values, and none are alkaline. Interpretive statements based on an assumption of alkaline paste pH for tailings should be corrected in the EIS. The EIS should verify data and interpretive statements that have been carried over from previous reports.

The data for rinse pH for the SMI (2000) data set were mistakenly plotted in Figure 3-14. A new figure 3-14 is in the FEIS. The data show the pH to be "near-neutral" as opposed to "alkaline". The paragraph in Section 3.8 has been revised accordingly.

1.55 Figure 3-13 on page 3-51 should explain why more recent data points are indicating more acid generation potential.

The NNP values do not show a trend through time, but an increase in the AGP reflects a higher pyretic sulfur level, which could result from encountering ores that are slightly higher in grade, or are higher in pyrite content. Figure 3-13 has been modified and new data is included in the FEIS.

1.56 Page 3-58 should explain why zinc is not liberated in the milling process if argillite contains abundant amounts of it.

The discussion in the “Tailings Runoff” subsection of 3.8.7 refers to the elevated zinc concentration contained in runoff water. In this context, the argillite refers to the construction rock used for constructing roadways. The text has been modified to read:

The higher average zinc concentration in runoff is thought to result from the higher concentration of zinc that is released from construction rocks (argillite) used in the tailings area, which themselves contain abundant zinc.

1.57 Page 3-94 should explain why Table 3-14 contains only pre-mining data when data is collected annually.

Table 3-14 has been expanded to include current data.

1.58 Page 4-3, Section 4.1.1 - The discussion of effects in 3 is also included in 1. The final EIS should consolidate these discussions.

Bullet # 1 has been rewritten and bullet # 3 eliminated.

1.59 Page 4-11 should explain why the model developed by Environmental Design Engineering did not consider carbon addition.

Carbon addition was indirectly utilized in EDE’s model, in that the outcome is based on wet well data reflecting on-going sulfate reducing processes. Section 4.5 was modified to discuss this.

1.60 Page 4-11 should contain a flow chart identifying what models are used for different points in the hydrologic cycle (e.g., precipitation, infiltration, etc.).

Figure 18 of Appendix A provides this depiction of the model used for each component of the mass load model. A simplified version of this figure has been added to the FEIS. See Chapter 4, Figure 4.3.

1.61 Page 4-13. See comments above from Chapter 3 on comparing the freshwater AWQS and technology-based loading limitations.

See Response 1.1. Additionally, Section 4.5 was clarified to compare the freshwater and marine water AWQS.

1.62 Page 4-14 states that Kennecott Mining will continue an appropriate method of water treatment until the tailings effluent can be discharged without treatment so that applicable AWQC are met. The draft EIS never fully identifies applicable AWQC, instead making comparisons to both freshwater AWQC and the loading limits of the current permit for discharges to marine waters (not the marine water AWQC).

See Response 1.1. Additionally, Section 4.5 was clarified with discussion of results from the water quality models for all alternatives.

1.63 Page 4-14 should state how surface water runoff from the pile would be treated.

Section 4.5.1 has been modified to provide additional discussion on impacts to surface water quantity in the three receiving drainages.

1.64 Page 4-16. Table 4-2 and other water quality tables should highlight the text differentiating the tables (e.g., underdrain flow and downgradient groundwater).

Table 4-2 headings have been modified.

1.65 Page 4-18 should explain Table 4-2.

Sections 4.5.1 through 4.5.4 have been clarified to offer a clearer explanation of Table 4-2.

1.66 General. The EIS shows that the level of some pollutants for all alternatives would exceed water quality standards. EPA will object to degraded water quality. The EIS must show how the preferred alternative would meet water quality standards.

See Response 1.1 regarding hierarchy of compliance points. The FEIS shows how the Alternative C would meet water quality standards.

1.67 Pages 4-26 and 4-27 contain the same table. The EIS lacks a table showing the effect of Alternative C on water quality for antimony, chromium, copper, lead, mercury, nickel, selenium, and silver. This water quality information for the preferred alternative is critical.

This was a printing error and has been corrected in the FEIS.

1.68 Page 4-43, Section 4.10 states that any discharge will be required to meet the AWQC for the protection of the marine uses (listed in 18 AAC 70.020). This document, however, never uses these standards for comparison purposes. The tables in Chapter 4 use the freshwater criteria and the loading limits of the current permit. The loading limits of the current permit use an authorized mixing zone making the technology-based limits, which are not subject to mixing zones, more stringent than the water quality-based limits for many parameters.

Please see Response 1-1 and other responses on this topic.

1.69 Like the environmental analyses in 1983, 1988, and 1992, the 2003 DEIS assumes that acidification will not occur in the tailings pile. 2003 DEIS at p. 3-51. However, subsequent to those earlier analyses, monitoring disclosed significant acid generating potential in the tailings. For example, the 1999 Shepherd-Miller report, Technical Review ARD/Metals Leaching and Freshwater Monitoring Plan, Greens Creek Mine, concluded that the existing tailings at Greens Creek are acid generating and that acid and heavy metals could potentially threaten the ground and surface water on the National Monument. Despite this newly discovered evidence, the DEIS completely ignore this significant risk of harm.

The FEIS incorporates all of the information and analyses contained in the SMI report, and the technical analyses were conducted by the same individuals, Scott Benowitz and William Schafer. The SMI report indicated that the tailings present a risk of acidification after a long lag period of up to 50 years if they are not managed in a way that mitigates the ARD potential. Placement of an engineered cover to reduce the flux of oxygen and water is considered to be an effective means of mitigating ARD risk. Consequently, the FEIS correctly concludes that ARD is not expected for any of the alternatives.

1.70 Two commenters indicated that instead of addressing the problem of acid generating potential in the tailings, the Forest Service relies completely on the success of the reclamation plan. It assumes that the soil cap required in the plan will mitigate impacts by controlling or preventing acid mine drainage. As mentioned above, there cannot be such a high degree of certainty in the success of the reclamation plan. There is a significant risk of harm to the environment that the Forest Service fails to consider when it relies on a reclamation plan that assumes that “once the cap is in place, runoff water will not come in contact with tailings.” 2003 DEIS at p. 2-29. There is a significant risk that the reclamation plan will not work and result in substantial harm to the environment. The DEIS dismisses this risk with a one-sentence assertion that any acid drainage resulting from a failure of the cap “should” be remedied by adding lime to the surface. 2003 DEIS at p. 3-51. This assertion is unsupported by any analysis and does not meet NEPA’s requirement that the Forest Service insure the scientific integrity of the discussions and analysis in the DEIS.

The descriptions of Alternatives C and D in Chapters 2 and 4 of the FEIS directly address the potential of acidification in the tailings through the addition of carbon or calcium carbonate to the tailings. This analysis concludes that the reclamation cap will be highly effective in minimizing the diffusion of oxygen or water into the tails. Remediation in the case of unexpected acidification is addressed in Chapter 3, Section 3.8.5.

1.71 Two comments were received which had slightly different wordings of the following comment: There are two critical assumptions used in the water quality modeling that may not hold true:-First, the engineered oxygen-barrier cover will work, and will work at 100% efficiency for the indefinite future. Although the design of the cover is probably the best approach for isolating the waste, both tailings and waste rock, given present technology, it is nonetheless unproven technology. It depends on maintaining a saturated clay oxygen-barrier layer to be effective. Construction flaws, a long dry spell, or accidental breach of the cover (from a landslide, falling trees, etc) could allow oxygen to penetrate the waste more deeply than modeled.-It is stated in the description of the oxygen diffusion modeling: "… acidification … is not expected to occur in tailings in the field because runoff and infiltration prevents acid salt accumulation. After placement of the engineered soil cover, the reduced supply of oxygen will slow sulfide oxidation thereby controlling salt accumulation." (DEIS, Appendix B, Hydrology and Geochemistry, p. 31); and, "… the tailings acidification risk is considered minimal. However, the data upon which this analysis is based are variable, and the underlying assumptions have a high degree of uncertainty making this estimate subject to error." (DEIS, Appendix B, Hydrology and Geochemistry, p. 29) This cover must work essentially in perpetuity. If the integrity of the cover does not hold, significant environmental contamination will result.-The second assumption is that the addition of carbon in the preferred Alternative C will maintain a reducing environment in most of the tailings. The mass balance model assumes: "Water will become completely reduced as the added carbon initiates sulfate reduction." (DEIS, Appendix B, Hydrology and Geochemistry, Table 11, Alternative C, p. 61); and, "Water will remain reducing so that concentrations will change little." (DEIS, Appendix B, Hydrology and Geochemistry, Table 11, Alternative C, p. 61)-The use of carbon to induce and maintain a reducing environment in the tailings has been utilized to reduce the levels of contamination in heap leach piles, but it has not been demonstrated that the technique will work over the long term – i.e. in perpetuity. If the reducing environment is not maintained as predicted by the stochastic mass load model, zinc (and other metals?) levels may not be reduced by the sulfate reduction reactions sustained by carbon addition – a reduction factor of approximately 500. If this reduction factor in the model is inaccurate, or if the carbon addition does not work over the long term as anticipated, zinc and other metals levels could increase significantly, possibly necessitating water treatment.

The EIS interdisciplinary team considered the above contingencies. The analysis concludes that the engineered cover will provide adequate mitigation of long-term ARD risk.

The commenter is correct in noting that the long-term environmental condition of the tailings depends on the continued performance of the engineered cover in reducing oxygen entry into the pile.

Adequate mixing of carbon and uniformity of the sulfate reducing reactions are model assumptions for Alternative C.

The analysis concludes that if carbon cannot be delivered to the interstitial solution within the pile, or if carbon addition fails to stimulate sulfate reduction to the degree that currently occurs in the tailings saturated zone that zinc levels may be higher than predicted by the model. If this occurs, then water treatment could be used to reduce zinc concentrations. However, a more likely scenario would be for the water from the underdrains to be collected and discharged to a marine discharge point, which would meet all applicable AWQS. It should be noted that under a “worst case” scenario, whereby the carbon system did not work, then the underdrain water would require a minimum dilution of 50:1 (as per Alternative A).

1.72 Section 3.6.6 – Marine Water Quality - From a description of marine water quality in the DEIS, it appears there is significant lead contamination. “Limited ongoing baseline marine water quality studies show that lead concentrations in Hawk Inlet and outside the sill vary, with location, from below detection limits to near acute levels (RTI, 1998).” (DEIS, p. 3-15, emphasis added) However, it is unclear from this description where the lead contamination is occurring.- Recommendation: A more thorough description is needed in the EIS to explain where this contamination is occurring, the source of the contamination, and what measures can be taken to minimize or eliminate the contamination.

Descriptions of long-term monitoring studies in Chapter 3, Section 3.6, were expanded to include methods, timeframe, frequency and results of sampling sediments, tissue, and water. This section was moved into Section 3.13, Marine and Aquatic Ecosystem. Data tables summarizing results from these studies were added.

1.73 Section 6.2 – Mass Load Model Results, Appendix B – Hydrology and Geochemistry: The 5 th of 6 paragraphs on Page 63 contains the following sentences: “Contact waters are assumed to instantaneously mix with surface runoff from the pile and downgradient groundwater, and that mixing will be complete by the time the waters reach a compliance location prescribed by the regulatory agencies. This could be accomplished using a treatment works that would utilize various chemical and physical processes such as oxidation, adsorption, dilution and dispersion that may occur in surface water or groundwater downgradient of the tailings facility.” The first sentence refers to mixing, while the second refers to water treatment. It appears that there may have been some material deleted between these two sentences. Please clarify the wording/meaning of this paragraph.

This paragraph is meant to explain that after closure, water from the underdrains can be mixed with surface and groundwater downgradient of the site in a variety of ways. Depending on how the water is managed (e.g through an infiltration gallery) the resultant chemical concentrations may be affected by chemical processes such as sorption, or by physical processes such as dilution and dispersion. The mass load model predicted the concentration at the compliance point by assuming that water mixes fully with downgradient surface and groundwater, and that all constituents are chemically conservative.

1.74 The Note on Page 67 states: NOTE: For all alternatives and tables - the hardness downgradient of the tailings facility was calculated in the mass load model. Consequently, the predicted hardness used to calculate allowable metal concentrations was the predicted hardness in the combined drain water and receiving water. Was the hardness used in the mass load model calculation limited to a maximum of 400 mg/l as required by EPA?

Yes, hardness was calculated from the modeled concentration of calcium plus magnesium, and if the calculated hardness was greater than 400, then a hardness of 400 was used in the equations for determining metals freshwater chronic criteria. Additionally, the revised tables use the 2003 Alaska water quality standards, which were recently revised, and the dissolved criteria are used.

1.75 2.2.1 Water Management During Active Operations: This section suggests a new water treatment plant is needed. Why is this necessary? Would any of the alternatives cause an increase in the quantity of water needing to be treated during the life of the mine? Would any of the alternatives cause a change in the quality of the current water collected for treatment such that a different type of wastewater treatment plant is needed during the life of the mine? Does the current wastewater treatment plant have enough capacity to fully treat the increased run off from the expanded tailings impoundment, and all collected storm water during a 25 year, 24 hour runoff event? Recommendation: The DEIS needs to assess the current and future wastewater treatment needs vs. the adequacy of the existing infrastructure and provide a full explanation. The bond calculation needs to cover the cost of any additional wastewater treatment facilities during operation or in a long-term closure plan.

See Responses 1.1, 1.4, and 1.22.

1.76 Section 2.4.1 Water Quality-The DEIS mentions or implies perpetual treatment will be needed to prevent water quality violations with discharges from the mine (pg 2-36, 2-37). In the section describing the effects of alternative C it is stated that “elevated arsenic and antimony that are predicted by the model are likely to be removed from solution when the water from the under drain contacts the atmosphere causing iron and manganese compounds to chemically precipitate, adsorb arsenic and antimony, and settle from solution” (Page 2.36- 7). The effects of this precipitate on the environment, biota and other water uses (drinking water, recreation, etc.) need to be described. Recent literature shows that metal precipitate is still biologically available. Recommendation: The bond needs to be re-calculated to include the costs of perpetual treatment of all managed waters, fresh and salt.

The chemical reaction described would occur upgradient from the compliance location in order for it to be considered effective. Hence, there would be no effect on the environment.

1.77 Section 3.6.7 Metal Concentrations in Seafloor Sediments and Biological Tissues- There is a clear indication from the data cited in this section that metals levels are elevated near the mine outfall and at other sampling sites (the text says acute levels are reached but does not discuss this statement). The discussion in this section is too limited to fulfill its stated goal of "determining whether mine operations caused any increase above natural levels of metals in sediment and tissues of organisms sampled." In addition to fully determining if existing metal levels in the sediments are causing problems, the expected increase in metal loading to Hawk Inlet from each alternative must be calculated. The sediment concentrations of heavy metals at the background station (S-2) showed no substantive change compared to sample sites S-1. However, metal levels in biota showed an increase at all three sampling sites. Further investigation needs to be made to determine if station S-2 is really unaffected by mine operations and thus can truly be used as a background stations for comparisons. Recommendation:-Available data needs to be presented in a table showing metal concentrations in sediments and biota. Please include sediment criteria values (for example; NOAA PELs, Washington State, British Columbia) in the table for comparison to evaluate how local concentrations compare to regulatory values.-Metal concentration increases need to be fully evaluated, including any speciation or biological transformations of metals (mercury and selenium in particular).-Methyl mercury values need to be sampled in sediments and biota to determine concentrations and then food web impacts must be evaluated.-Complete biological surveys need to be conducted to determine the health of the benthic invertebrate and fish communities.

See clarified discussion under Chapter 3, 3.13, Marine and Aquatic Ecosystem. A discussion on metals and chlorine toxicity to aquatic life was added to Chapter 3, Section 3.13, Marine and Aquatic Ecosystem. Baseline and toxicity testing data from ADF&G technical report no 03-04 was provided in that section. Potential toxic effects of metals and chlorine on marine life were described discussed in Section 4.11.

A discussion on bioaccumulation and biomagnification was added to Chapter 3, Section 3.13 and Chapter 4, Section 4.11.

1.78 Two commenters indicated that 3.7 Geology and Geochemistry should include monitoring information and water quality sampling, or source control measure taken to control surface water discharges. Include a discussion of this information along with a description of any surface and groundwater and biota sampling conducted in other know seeps including CC Creek, Further Creek, and Proffett/Franklins Creek. A risk assessment of the impacts to the local marine environment must be conducted to determine whether mine operations are now, or will by the end of the mine life impact marine sediments and biota.

Evaluate influence of mine operations on background sampling locations. If there is influence from the mine re-locate describe how the monitoring information will be interpreted and consider changing the background sampling sites. Determine what the heavy metal load will be to the marine environment for the life of the mine and complete an impact assessment on biota with this information. Figure 3.9 does not show sample site S-3, nor does figure 3.6. Please provide a map of this sampling location.

Section 3.8.6 describes how surface water runoff from the tailings pile is collected and diverted to the water treatment plant. Information about CC Creek, Further Creek, and Proffett/Franklins Creek is described in Section 3.8.2.

1.79 3.8 Water quality-Will increasing the size of the tailings impoundment increase the seepage from underneath or along side the facility? Recommendation: If so, calculate the additional load to ground and surface waters.

This is answered in Section 4.5 of the FEIS.

1.80 Further seep is showing elevated levels of sulfate and conductivity, while pH was significantly depressed to 4.0 (Letter McGee to Oelklaus, October 10, 2001). The DEIS identifies several other seeps originating from the tailings impoundment, including CC Creek, Further Creek, and Proffett/Franklins Creek. Page 3-29-30 discusses a direct discharge of surface water and groundwater coming from the tailings impoundment and going into Cannery Creek and Tributary Creek. All seeps should be considered point sources. Recommendation: EPA must consider each seep to surface waters as a point source under their NPDES permit requiring full monitoring and calculated water quality based effluent limits.

The document describes the groundwater flow that finds its way into the wet well system, which in turn reports to the water treatment plant and is discharged under the NPDES permit. See the discussion of Groundwater Flow Systems in Chapter 3, Section 3.7.4. The Greens Creek NPDES permit is scheduled to be renewed in early winter of 2003 and EPA will make decisions on the considerations of seeps in that document.

1.81 Table 3-5 shows data from monitoring wells located down gradient from the tailings impoundment. There are several metal levels that are in exceedances of the WQS (e.g. site MW-01-15C, MW-01_06A, MW-01-06B, MW-01-08, MW-01-03A dissolved silver; site MW-01-3B dissolved selenium; site MW-96-4, MW-01-3A dissolved arsenic; MW-01-08 dissolved copper, etc.). Sulfate, TDS, and conductivity were elevated at several sites. The method detection levels used for silver and cadmium appear to be above the WQS, and thus inappropriate for determining if there are exceedances of WQS. Recommendation: 1) The full extent of seepage from the tailings impoundment to ground and surface water must be quantified and reported. EPA and ADEC must consider each seep to surface waters as a point source under their NPDES permit requiring full monitoring and calculated water quality based effluent limits. 2) All analytical methods must use low enough detection levels to determine if there are exceedances of the WQS.

In the FEIS, the data in Table 3-5 reflects samples collected between 1988 and 2003. During that period, AWQS and detection levels have changed dramatically. To determine whether, "several metals (that) are in exceedance of the WQS" it is necessary to know the date of the sample and what the standard was at that time. If the standard is hardness-based, the hardness of that particular sample must also be known before the standard can be calculated.

The FWMP (GPO Appendix 1) outlines the accepted procedure upon which the detection level is calculated. This procedure assures that appropriate detection levels are used for water quality analyses.

See response 1.78 and Chapter 4, Section 4.5 Hydrology, of the FEIS.

1.82 Table 3-6 shows a summary of FWMP sites above and below the tailings impoundment. Several water quality parameters and metal levels exceed WQS (e.g. FWMP site #9 pH of 4.2, dissolved cadmium, copper, lead, mercury, silver, and zinc). These discharges should have the same type of analytical and source control action plan as was developed for further seep. The DEIS identifies reactive waste rock as the source for some of the contaminant leaching (pages 3-46-47). This section describes water quality impacts from reactive waste rock that is located throughout the mine site. The waste disposal permit, 0111-BA001 states that "This permit may be modified to include other mine related disposal areas or waste materials if the Department determines that there is an environmental problem associated with the management of those areas or waste materials." (Page 5). ADEC must recognize that this evidence of water quality impacts from waste rock deposition throughout the mine site gives ample information to justify including all waste rock disposal sites in the waste disposal permit. In addition, all discharges to surface water should be considered point sources and regulated under the NPDES permit. Recommendations: Regulatory agencies should require an action plan from KGCMC that quantifies the source and amount of contamination entering into surface waters below the tailings impoundment. ADEC must include all waste rock disposal sites throughout the mine site in the waste disposal permit with full monitoring and bonding requirements. EPA must consider each seep to surface waters as a point source under their NPDES permit requiring full monitoring and calculated water quality based effluent limits.

Table 3-6 has been updated to reflect the sampling period. The action plan for the FWMP sites included in this table is described in KGCMC, GPO Appendix 1 (found in the planning record).

The section referred to (Section 3.8.2 of the DEIS) refers to the drainages surrounding the tailings pile only.

The ADEC, 2002, Draft Waste Management Permit (Appendix D) includes production rock disposal facilities sites 23 and D, and underground disposal of wastes. As noted by the commenter, the Waste Management Permit is administered by the ADEC who determines which sites to include under the permit.

In November, 2002 staff from ADEC, accompanied by Forest Service and KGCMC staff, inspected sites on the Kennecott Greens Creek Mine property not covered by the ADEC waste disposal permit. This inspection was conducted as part of an on-going effort to understand areas that may pose a short or long-term potential for acid rock drainage (ARD) and metals leaching (ML).
Those sites visited during the site inspection were:
Site 1350 (Initial mine underground development/exploration)

- Site 960 (Mine development waste rock)
- Site 920 (Mill site)
- Site 860/C (Mine safety and laboratory buildings)
- Site D berm (Adjacent to Greens Creek stream)
- Pit 405 (B-road construction material)
- Site E (Mill site development material and waste rock)
- Pit 6 (Mile 4.6, B-road)
- Pit 174 (Mile 3.3, B-road)
- Zinc Creek Bridge Abutment (Mile 3.0, B-road)
- B-road roadbed, mile 1.8 to 2.5
- Old access road to the south of the tailings site seepage pond
- Pit 5 (Tailings facility, location of wastewater plant)
- Pit 7 (Mile 1.8, A-road)

These sites included sites that had received pyritic rock either from mining or from road building, a site from which pyritic rock was removed, and 5 rock pits that contained rock from the earthwork involved in the development of disposal sites or mine related facilities (one of which had also received pyritic rock).

ADEC staff reviewed the historical site-specific information maintained in the KGCMC database and files for this report as well as the monitoring information:

1) Technical Review ARD/Metals Leaching and Freshwater Monitoring Plan Greens Creek Mine, Shepherd-Miller, Inc., February 18, 2000
2) General Plan of Operations, Appendix 1, Freshwater Monitoring Plan
3) Annual Report to ADEC, April 2002
4) Aquatic Biomonitoring at Greens Creek Mine, 2001
5) Kennecott Greens Creek Mine Production Rock Site Characterization Study, March 1995
6) Update of Information and Action Plan on Seeps West Of the Current Tailings Disposal Facility by KGCMC, January 2002

7) General Plan of Operations, Appendix 11, Attachment C, Inactive Site Environmental Monitoring Program

The ADEC inspection report (ADEC, 2003) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

All point source discharges from the site are regulated under the NPDES permit. The EPA is a cooperating agency in the preparation of this EIS and will use this analysis to determine the scope of the NPDES permit to be reissued in early winter, 2003. Also, see Response 1.79.

1.83 Section 3.8.5 Tailings Geochemical Properties-The contact water has elevated levels of calcium, sulfate and magnesium ions (page 3-54). Recent studies have shown that Total Dissolved Solids (TDS) that contain calcium are toxic to fish at levels as low as 250 ppm (Stekoll 2003). Is TDS sampling conducted in surface waters affected by runoff and seepages from the mine? What are the TDS constituents and concentrations in local streams with spawning populations?

This EIS deals with the proposed expansion of the tailings pile. Contact water from the tailings pile is collected in the drain system and run through the water treatment system. No contact water from the pile reaches surface waters or streams. We are familiar with the findings regarding calcium in "Effects of Total Dissolved Solids on Aquatic Life – Correlation of Microtox, Agal, and Salmonoid Assays, Stekoll et al, 2003.

1.84 Reasons for Caution when Predicting that Water Treatment will be needed for only 7 years: In addition to the modeling assumptions discussed above, the ADEC's financial assurance calculation assumes that water collection and treatment will only be needed for 7 years following closure of mine operations. There is no technical basis presented for this assumption. There are, however, several possible reasons why water collection and treatment may be required for a considerable period after mine closure: •The tailings may have more acid-producing potential than has been anticipated. As more data on acid generation potential has been accumulated, the acid-producing potential has increased. "The evaluation of tailings conducted by Vos (1990) and evaluated by Smith (1991) indicated that the tailings may not become acidic, though the results were not internally consistent and some tests suggested a risk of ARD development. Recent grab samples of tailings (Figure 8) show that many samples have a lower NNP than the Vos tailings sample. Consequently, the overall tailings are more safely considered to have a risk of generating locally acidic conditions, especially near the surface where oxidation is more prevalent." (DEIS, Appendix B, Hydrology and Geochemistry, p. 24) and; "The overall tailings acidification risk is considered minimal. However, the data upon which this analysis is based are variable, and the underlying assumptions have a high degree of uncertainty, making this estimate subject to error." (DEIS, Section 3.8.5, p. 3-51) The onset of significant metals production could be well after the nominal 30-year reclamation period, and at a point in time when significant bond monies have been returned to the mine operator, or when there is no longer a mine operator to pay for unanticipated problems. "It may be that the average lag period (before generation of acidic pH levels) for the operating tailings facility is in the range of 20 to 50 years." (DEIS, Appendix B, Hydrology and Geochemistry, p. 24) • The tailings facility is not lined, and water can enter or exit the tailings. The extent of the clay-confining unit, even with the assumption that the clay does form an effective barrier to the migration of water in the areas where it is present, does not cover the entire area of the tailings facility. (DEIS, Figure 3-9, p. 3-27) Even if a liner were to be placed over all areas that are not underlain by clay in the expansion area, there are still areas under the present tailings that have neither clay nor liner. • It is assumed that the groundwater situation under the tailings area is one where water comes into, not out of, the tailings: "Groundwater in aquifers beneath the pile has an upward gradient beneath the current tailings and also occurs under flowing artesian conditions on the southeast side of the pile. Consequently, upgradient groundwater discharges upward into portions of the underdrain system and mixes with interstitial water that is flowing downward from the tailings stack." (DEIS, Appendix B, Hydrology and Geochemistry, p. 17) However, as the height of the tailings pile increases (from 80 to 160 feet, for the preferred Alternative C), the hydrostatic pressure from the water draining from the tailings pile will increase, and might conceivably create a flow into groundwater in some areas. This might let contamination seep into areas where it is presently not seen – requiring collection and possibly treatment. All of these factors add to the risk that the USDA, ADEC and ADNR, and the taxpayers that provide funding for these agencies, could be liable for a cleanup of contamination should the geochemistry of the tailings and/or waste rock prove to be worse than predicted. As a result, the responsible agencies should be very risk-averse in determining the appropriate level of financial assurance for this project, because the long-term financial risk is significant.

The duration of the monitoring is set by the Alaska Department of Environmental Conservation in its Waste Management Permit. Sections 2.6 through 2.13 of the ADEC 2002 Draft Waste Management Permit (Appendix D of the FEIS) specify visual, groundwater, surface water, leachate, biological, and post closure monitoring requirements. Prior to cessation of monitoring, KGCMC must demonstrate ".... that all downgradient monitoring stations have been in compliance with Alaska Water Quality Standards (AWQS) for at least 3 years. Additionally, results of monitoring at internal sites must corroborate the finding that water quality downgradient of the facility will not change in the foreseeable future. DEC retains the right to extend monitoring requirements as long as it is needed.

1.85 Water Quality Analysis in Greens Creek: Site 48- Upper Greens Cr (background) vs Site 6- Middle Greens Cr (above site 23): Site 48 and site 6 are compared to determine if runoff from the mill site is affecting Greens Creek. Dissolved zinc levels are elevated at site 6 vs. site 48 (statistically significant =SS). This may be an indication of influence from mining operations. The FWMP should not dismiss this possibility. Metals leaching, especially zinc, occurs readily in some ore bodies, and can have detrimental effects on aquatic life. This trend must be carefully followed. Hardness levels are increasing at site 48 (SS) and several metal levels decreased in Water Year 2000. It is important to try to determine why the metal levels have changed at site 48 because the Forest Service uses this site as a background in which to compare downstream sites to assess impacts (site 6 and 54). If site 48 is influenced by mine operations then it is not a background site causing in data interpretations and conclusions in the FWMP to be questioned. Conclusions: Determine if water quality changes are to operational changes, source control, sampling or analytical techniques. Determine if site 48 is an adequate background station. Site 48- Upper Greens Cr (background) vs. Site 54-Lower Greens Cr (below site 23): Site 48 and site 54 are compared to determine if runoff or leachate from mill site or production rock sites are affecting Greens Creek. pH concentrations showed a statistically significant decrease between site 48 and site 54, all readings were in compliance with WQS. Conclusions: Dissolved zinc levels in Greens Creek are increasing and pH levels are dropping between site 48 and site 54. The validity of site 48 as a background site needs to be re-confirmed. Site 23 and site D. Monitoring well 50(up-gradient of 23) vs. 51 (down-gradient in 23) vs. 53 in site D Concentrations of conductivity, hardness, total alkalinity, dissolved cadmium, copper and zinc, and total barium are higher at site 51 than at site 50. There are exceedances of the water quality standards at site 51 for pH, barium, nickel, silver, and dissolved and total recoverable zinc. pH at site 51 is trending down. There are exceedances of water quality standards at site 53 for pH, silver, zinc, and dissolved cadmium. pH at site 53 is trending down and is consistently below water quality standards. Hardness is trending up. Conclusions: Water quality standards are being exceeded at these sites, while pH is trending down. These sites are being impacted by production rock. Greens Creek is only 100 feet below the berm at site D and has the potential to be impacted. No acid base accounting was conducted on the berm materials, even though they came from pit 405 which is known to be acid generating. This work should be completed in 2003, or the berm material removed to an adequate containment location. An additional sampling location in Greens Creek should be added directly below site D berm.

Chapter 3, Sections 3.7 and 3.8, and Chapter 4, Section 4.5 and Appendix A of this FEIS address acid rock drainage and increased heavy metals concentrations connected to the tailings pile. Other portions of the mine have been addressed through previous EIS's or EA's as separate NEPA actions. The Alaska Department of Environmental Conservation's Waste Management Permit also addresses these issues for the entire mine. The ADEC inspection report of November 2003 (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

1.86 I have concerns about the tailings disposal and do not feel confident in the Plan. It seems that the major focus in the document concerning the tailings is how to treat the tailings, which is important. However, there is very little in the document concerning the liquid tailings coming through the pipe as far as what precisely is going to be in that tailings liquid and I would like the Forest Service to be specific in addressing that. It seems as though there are a lot of assumptions that the plan is ok. Although the document contains a great deal of information, it seems sketchy to me that it will truly actually work and not be toxic to the environment.

. The tailings from the mill are dewatered at the mill and transported to the disposal site by truck where they are spread and compacted. Very little mill water remains in the tailings. The main focus of this EIS is on the quality of water that comes in contact with the tailings after placement on the pile. See Section 4.5, Hydrology, of the FEIS, and Appendix A, *Hydrology and Geochemistry of the Greens Creek Tailings Facility.*

1.87 Disposal Facilities Sites 23 and D) Waste Rock Site E "Distal Sites" are generating significant metals, moderate sulfate, with neutral pH. There is no monitoring required for Site E in the present monitoring plan being adopted as part of the ADEC solid waste permit. In addition, Site E, which still does not have a final reclamation cover, is not covered as a part of the permit. Sites 23, the active waste rock disposal site, and Site D, a waste disposal site that is no longer being used, like Site E, are both included in the permit and monitoring. Recommendation: At a minimum, periodic groundwater and surface water monitoring at Site E should be required in the monitoring plan. Site E, a waste rock disposal site with potentially acid generating material that has not been closed, should be included in the permit as are the other waste rock sites 23 and D.

Chapter 3, Sections 3.7 and 3.8, and Chapter 4, Section 4.5 and Appendix A of this FEIS address acid rock drainage and increased heavy metals concentrations connected to the tailings pile. Other portions of the mine have been addressed through previous EIS's or EA's as separate NEPA actions. The Alaska

Department of Environmental Conservation's Waste Management Permit also addresses these issues for the entire mine.

The ADEC inspection report (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

1.88 KGCMC's major concern is the carbon amendment study advocated in Alternative "C" and how the carbon amendment research is interpreted. The Alternative "C" definition on page 2-14, Section 2.1.3 and subsequent carbon addition section on page 2-21 explain the framework for a Sulfate Reduction Monitoring Program (SRMP). KGCMC interprets the SRMP as a program to determine if any additional carbon amendments are needed over and above the existing additions that are ongoing at the site. Thus, the program would study varying degrees of additional carbon amendments and their effectiveness in sulfate reduction, starting with no amendment and increasing from there. –

The purpose of the SRMP, as outlined in Appendix B, *Sulfate Reduction Monitoring Program Outline, 2002,* is to determine the amount of carbon needed to fuel sulfate reduction for a requisite time post-closure to ensure water quality in perpetuity. Please see Chapter 2, Section 2.4.3 Alternative C for a summary of the SRMP and Appendix B for a detailed outline.

1.89 Notwithstanding the research period and subsequent plan submittal to the Forest Service, sulfate reduction will be difficult to assure in perpetuity as currently required by the DEIS Alternative C definition. KGCMC feels that this assurance requirement is exceptionally stringent given that another viable alternative exists for ensuring compliance in the effluent discharge, namely continuation of discharge to the marine environment, the use of which is indicated in the DEIS document as having negligible effects in any of the alternative options [DEIS pages; 4-15 (Alt. A), 4-21 (Alt. B), 4-25 (Alt. C), 4-29 (Alt C)].

Thus, as a consequence of these concerns, KGCMC suggests a hybrid alternative to Alternative C to allow for future best use of technology at the tailings disposal site:

Retain Operational Flexibility. By locking in a SRMP program within the EIS, the Forest Service may inadvertently limit the company's use of the best available technology as time progresses. The flexibility needed to continue to determine the best methods to handle final tailings water effluent after closure is already inherent in the requirements of the State of Alaska Waste Management Permit (WMP), which includes 5-year environmental audits. Both the General Plan of Operations (GPO) and the WMP contain KGCMC commitments to reevaluate and determine what is the best technology for the Greens Creek operation. Such technology assessments include the TIEMP program and compliant water discharges. Given the Baker Hydrology and Geochemistry results presented in the DEIS, it is clear that a sustainable tailings effluent discharge method is available to assure water quality compliance, at a minimum, through continued marine discharge after closure. KGCMC does not agree with a requirement of the SRMP program within the structure of the EIS, and recommends an alternative to include the SRMP program (as described in Appendix C in the DEIS) into the updated GPO. In this manner, the requirement continues to exist in the framework of flexibility and cooperation with the agencies, while allowing the company to fully participate in the development of a SRMP program suited to the site rather than a dictated program that may result in unwarranted and unforeseen limitations on operations and/or yielding no appreciable environmental benefit. KGCMC also suggests that if the Forest Service continues to advocate the SRMP in the FEIS, then the FEIS must present full definitions and requirements for that program. The FEIS presentation should also discuss the intent of the program within the EIS structure to limit future misinterpretations. Alternatively, the SRMP developed through the cooperative process proposed in the above paragraph would contain this information. -.

Comment noted. See Response 1.88. In crafting the ROD, the Forest Service has the ability to choose components from the various alternatives to achieve the best final result.

1.90 As a part of the metrics required for site water quality requirements, consideration should be given in the EIS to setting the compliance points at the lease boundary to eliminate further confusion regarding this issue and to maintain consistency with the companion Alaska Department of Environmental Conservation (ADEC) Waste Management Permit requirement. The last phrase under “Monitoring” on page 2-35 should also mention the nature of the limited modifications (e.g., the plan is being modified to add appropriate sampling sites).

Chapter 2, Section 2.2.3 Monitoring, has been clarified.

1.91 In the last paragraph on page 2-35, the discussion about Water Quality under Alternative A is somewhat confusing in that it suggests that the underdrain flow mixes with both surface and groundwater at a single compliance location, when in practice such blending occurs broadly within the Tailings containment area.

Chapter 2, Section 2.2.1 Water Management has been clarified.

1.92 In addition to ranges of concentrations, we believe Table 3-3 should include information about the period of time represented by the analyses and whether any of the data represents pre-mining water quality.

Table 3-3 has been re-named Table 3-4 in the FEIS, and has been modified to reflect the sampling time period. The sampling frequency has changed over the years, and is summarized in the FWMP. The values in Table 3-4 include pre-mine values, as stated in Section 3.8.1, Ground Water Quality. The average value shown in Table 3-4 reflects the entire time period. The average value is given for informational purposes. The location of these wells is shown in the revised Figure 3-11.

1.93 Section 4.5. Hydrology: The tables show model predictions of the concentration of selected constituents in underdrain flow. For all the alternatives, however, tailings seepage makes up less than half the underdrain flow. Therefore, we believe dilution is probably masking differences in the concentration of constituents in tailings seepage caused by the different alternatives. We suggest that an additional section be added to each of the tables to present the modeled concentrations in the undiluted tailings drainage. This would provide information on trace metal concentrations in the undiluted tailings drainage for comparison with State of Alaska Water Quality Standards

Table 3-10 has been re-named Table 3-11 in the FEIS. Tailings contact water chemistry is shown in Table 3-11. Section 3.8, Hydrology, explains that groundwater flows upward into the drain layer from the bedrock and till layers beneath the pile. This is conceptually shown in Figure 3-10. This water is collected in the wet wells and pumped to treatment. Due to this upward groundwater flow, tailings contact water will always combine with groundwater prior to entering the wet wells. Therefore, the tailings contact water chemistry will always be influenced by groundwater prior to leaving the facility. As there is no physical way to separate the two water sources the suggested comparison would not provide information useful to this analysis.

1.94 Section 4.5.3 Alternative C: Ensuring that the project area water quality does not decline helps protect local forested and scrub/shrub wetlands habitats, migratory birds, bald eagles, and resident and anadromous fish. Sulfate concentrations above the A WQS are predicted for Alternative C for 200 years. Without a trend analysis, it is difficult to predict if metals will also exceed A WQS. We suggest inclusion of a metals trend analysis in Section 4. In addition, a discussion of a mixing zone for metals should be addressed in the Final EIS, particularly as A WQS are presently exceeded.

The predicted sulfate concentrations for Alternative C are the same or below that predicted for all other alternatives including the No Action Alternative. Sulfate concentrations are predicted to be below AWQS levels for marine discharge. Please see Chapter 2, Section 2.2, Elements Common to All Alternatives, for the discussion of hierarchy of AWQS targets that has been added. The methods used to predict sulfate concentrations are the same methods used to predict metals concentrations in the effluent. Therefore, we have the same confidence in the predictions of sulfate and metals concentrations. See the sensitivity analysis in Appendix A, Hydrology and Geochemistry, Section 7.

The FEIS has been modified with an additional comparison of effluent chemistry versus AWQS that includes the use of a mixing zone. See Chapter 4, Section 4.5 of the FEIS.

1.95 Several comments asked for well sites and surface water quality sampling sites to be identified in an appropriate map figure.

Well identifications have been added to Figure 3-11

1.96 Figure 3-12 is used to reference the location of Surface Water Quality – FWMP Sites (Table 3-6). The sites are not shown or labeled on Figure 3-12. Recommendation: Show and label the FWMP sites on Figure 3-12, or at a minimum label the wells for which data in Table 3-5 is presented.

Figure 3-12 has been modified to show the names of the streams sampled.

1.97 NMFS 10. Section 3.6.6 indicates that "(m)arine water quality parameters were monitored on a regular basis" but does not provide any information on the frequency of monitoring, the specific parameters that are regularly monitored, or any changes in marine water quality that have occurred during the period that the mine has been in operation.

Descriptions of long-term monitoring studies in Chapter 3, Section 3.6.7 were expanded into a technical paper (Ridgway 2002) to include methods, timeframe, frequency and results of sampling sediments, tissue, and water. The summary of this paper was moved into Chapter 3, Section 3.13, Marine and Aquatic Ecosystem. Data tables summarizing results from these studies were added to the FEIS.

1.98 NMFS 19. Section 3.6.2, Surface Water Quality, states "(s)urface water quality has been evaluated from FWMP samples taken from Tributary Creek downgradient from the tailings facility and Cannery Creek upgradient and downgradient from the existing tailings facility (Figure 3-12)." Why Figure 3-12 is referenced here when neither Tributary Creek nor Cannery Creek are identified in Figure 3-12 is not clear.

This comment refers to Section 3.8.2 of the DEIS. The figure reference has been changed to reference Figure 3-7 which shows Tributary Creek and Cannery Creek.

1.99 NMFS 20. Page 3-45 states "The data from Tributary Creek revealed dissolved levels of cadmium, copper, mercury and zinc having values above AWQS…" but no information is provided about what these values were. The document indicates that "since 1990 these parameters have been analyzed at levels below AWQS." This statement is of only marginal value because the timeframe during which values exceeded AWQS is not specified, and the actual measurements are not provided.

The data in question is reflected in Table 3-6. The table has been modified to reflect the sampling period.

Chapter 2 Acid Rock Drainage (ARD)

2.1 A number of comments suggest that this EIS should expand to consider the entire mine site and process and specifically consider the issue of acid rock drainage from existing use of construction rock in roads and pads and from waste rock dump sites. Some of these comments also faulted the EIS for not developing alternatives which address the commenters perceptions of ARD risk from construction rock or waste rock.

Chapter 3, Sections 3.7 Geology and Geochemistry, 3.8 Water Quality, Chapter 4, Section 4.5 Hydrology, and Appendix A: Hydrology and Geochemistry of the Greens Creek Tailings Facility, and Appendix B: Sulfate Reduction Monitoring Program Outline of this FEIS address acid rock drainage and increased heavy metals concentrations connected to the tailings pile. Acid rock drainage from the other portions of the mine have been addressed through previous EIS's or EA's as separate NEPA actions. The Alaska Department of Environmental Conservation's (ADEC) Waste Management Permit (WMP) also addresses these issues for the entire mine.

The ADEC inspection report (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

2.2 Our primary concern is that an adequate long-term water quality monitoring plan be established. We believe that potential acid runoff or leaching could have negative impacts on fish, wildlife, and habitats in the project vicinity. There are a series of statements in the Draft. EIS discussing the uncertainty of tailings acidification risk that we believe support a recommendation for a monitoring program longer than the 30-year period discussed in the Draft EIS (Section 3.8.5, Page 3-51, and Appendix B, Pages 24 and 29). The Draft EIS identifies that the average lag period for acid generation is stated as 20 to 50 years (Appendix B). Therefore, a 30-year monitoring period may not be sufficient to detect any potential long-term consequences to surface and ground water quality. We recommend that the Final EIS extend the monitoring period to at least 50 years to ensure against delayed acid-generation in the tailings pile.

The duration of the monitoring is set by the Department of Environmental Conservation in its Waste Management Permit. Sections 2.6 through 2.13 of the Waste Management Permit (Appendix D of the FEIS) specify visual, groundwater, surface water, leachate, biological, and post closure monitoring requirements. Prior to cessation of monitoring, KGCMC must demonstrate ".... that all downgradient monitoring stations have been in compliance with Alaska Water Quality Standards (AWQS) for at least 3 years. Additionally, results of monitoring at internal sites must corroborate the finding that water quality downgradient of the facility will not change in the foreseeable future.
DEC retains the right to extend monitoring requirements as long as it is needed.

Chapter 3 National Monument Values

3.1 Notwithstanding the DEIS's failure to address the Congressional mandate as detailed in Section 503 of the ANILCA, the 1997 Tongass Plan also clearly requires protection of monument values. Given the agency's failure to complete an island wide comprehensive plan, we are gravely disappointed that this DEIS fails to deal in any meaningful way with the impacts of past, present and cumulative mining activities and acid mine drainage on Monument values.

Monument values are identified in Chapter 1 as a significant issue, which could lead to the formulation of various alternatives, as well as to the design of mitigation measures when needed. The footprint of Alternative C was specifically developed to minimize disturbed area within the Monument and the bulk of the document focuses on water quality, including acid rock drainage, both within and outside of the Monument. The Cumulative Impacts section of the FEIS Chapter 4, Section 4.17, has been expanded to address this concern.

3.2 Because Greens Creek operates in Admiralty Island National Monument, the mine must be held to the highest environmental standard and carry out its operations in a way that assures the long-term integrity of the Monument's extraordinary values. To date the Forest Service has failed to meet its obligations under section 503 of ANILCA. The preferred alternative will only worsen the existing significant water quality issues at the mine site and take the mine in the wrong direction, further from meeting the legal requirements that were established for managing Admiralty Island National Monument.

ANILCA recognized the valid existing rights related to the Greens Creek mine in 1980 when it designated the area of the Greens Creek drainage as a Non-Wilderness Monument rather than Wilderness. The Forest Plan includes a land use designation of Non-Wilderness Monument with a minerals overlay. (See Forest Plan, page 3-151) One of the goals of the minerals prescription is to insure that minerals are developed in an environmentally sensitive manner, and that other high valued resources are considered when mineral developments occur. After the completion of mining activities and restoration, the area is to be managed as according to the Non-Wilderness National Monument prescription. Please see section 1.6 of the FEIS for more detailed discussion.
Based on the analysis displayed in Chapter 4, Alternative C has the potential to improve short and long-term tailings effluent quality when compared to the No Action Alternative.

3.3 The proposed alternative is based on technology that has not been successfully implemented at other mine sites and relies on assumptions that admittedly have a "high degree of uncertainty." This approach is simply unacceptable and contrary to the statutory obligation imposed by Congress on the Forest Service to assure that the use of Monument lands leased by Greens Creek "not cause irreparable harm to … Admiralty Island National Monument."

The selected alternative, Alternative C (versus the proposed alternative that the commenter is referring to) is the alternative that incorporates carbon addition technology. All alternatives considered in this environmental analysis involve the use of the 4-layer engineered cap. Multiple layer caps are used to exclude oxygen and water in mines throughout the world. Covers similar to the engineered cover proposed at Greens Creek have been designed and constructed by Dr. Ward Wilson at numerous mine sites in British Columbia, Saskatchewan, and in subtropical regions of Australia. The design and performance of this cap is discussed in *Final Report – Waste Rock Cover Design, Kennecott Greens Creek Mining Company*, prepared by Unsaturated Soils Engineering Ltd., December, 1998 and is evaluated in *Cover System Performance at the Greens Creek Mine*, prepared by O'Kane Consultants, Inc. December 2001. Both documents are included in the planning record. Please see Section 2.2.2 Water Management during Closure and Post –Closure for additional discussion of the cap performance. The use of carbon is discussed in detail in Chapter 2, Section 2.4.3. in Appendix A, Hydrology and Geochemistry of the Greens Creek Tailings Facility, and Appendix B, Sulfate Reduction Monitoring Plan. Additional background has bee added to the SRMP that says: "Carbon addition to tailings as a means of supporting biological sulfate reduction has been evaluated, either directly or indirectly, at other mines. Three basin means of adding carbon to tailings have been described in the literature: as a carbon-rich layer in a cover, as an amendment to tailings, and as a naturally accumulating component of sediment in tailings closed with a water-cover. Tassé and others (1997) measured increases in pH, carbon dioxide, and methane and decreases in dissolved oxygen beneath a 2 m thick wood waste cover placed over the sulfide-enriched East Sullivan tailings. The site is located in northeastern Quebec. The primary advantage of the organic cover was the removal of oxygen prior to reaching the tailings. After placement of the cover the pH near the original tailings surface, which had acidified prior to cover placement, increased from 4.0 to 6.5 within 3 years. Groundwater downgradient of the site is expected to improve over about 10 years.

Elliot and others (1997) also evaluated various organic amendments for their suitability as organic covers placed over acidic tailings. Of the amendments tested (peat, lime-stabilized sewage sludge, municipal solid waste compost, and de-sulfurized tailings), the lime-stabilized sewage sludge was the most effective cover material, owing to the alkalinity that was leached from the cover into the underlying tailings. Li and others (2000) have performed extensive evaluations of tailings water covers at the Louvicort Mine in Quebec and the Falconbridge site in Ontario. Water covers were developed to reduce oxygen flux as is the case for the dry covers proposed at Kennecott. A secondary advantage of the water covers is the removal of oxygen due to decay of organic carbon in the sediments that accumulate above the tailings. Although these results are not directly applicable to Greens Creek, it does indicate that the rate of organic carbon decomposition is rapid enough to consume most of the oxygen that migrates through the water cover, which ranges from 0.4 to 2 moles $O_2/m^2/yr$, greater than the modeled oxygen flux through the soil cover at Greens Creek.

Canty (2000) demonstrated the effectiveness of adding composted animal wastes to acidic mine waters at an abandoned mine in Montana (the Lilly/Orphan Boy Mine). During baseflow periods, the treatment removes the majority of dissolved aluminum, copper and cadmium from the acidic water. Additionally, the organic material increased pH from less than 4 to near 7, and removed about one-half of the zinc. Treatment efficiencies were poor during the spring snowmelt period when flows dramatically increased, however. This application is seen as being more challenging than the Greens Creek tailings because the mine water was already acidic, and the organic substrate could not be uniformly mixed with the mine water.

In the closest analogue to the Greens Creek facility, Chtaini and others (1997) tested the use of paper mill waste as covers or additives to acidified tailings as a means of abating the release of metals and acidity. Laboratory column and field-scale tests were conducted on paper mill waste covers with and without partial incorporation of paper waste into the underlying tailings. In field test plots, the paper mill waste cover with 30 cm of incorporated paper waste increased the pH of pore water (in the amended layer) from 4.7 to 7.0, and decreased zinc levels from 162 mg/L to below instrument detection level. Similar reductions in copper, cadmium, and nickel also occurred. The applied organic wastes did not remove all of the oxygen from the system, but maintained neutral pH and low metal levels through dissolution of alkalinity in the waste, and sulfate reduction reactions."

Also, see Response 3.2.

3.4 The response to the issue of monument values in the DEIS completely misses the point. Acid mine drainage and heavy metals cause extreme environmental harm that lasts for hundreds of years. These metals and acid are mobile once they leach from waste piles. Therefore, the long term environmental risk to Monument values exists whether or not the tailings pile is expanded into Monument lands or into lands directly adjacent to the Monument. The Monument value issue revolves around the level of precaution and protective technology that the Forest Service employs when it allows waste to be placed on and around Monument lands. The issue clearly is not how much of the pile ends up actually being placed within Monument boundaries, but whether steps the Forest Service require Kennecott to take will insure that Monument values are protected from irreparable harm.

The impact of disturbance within the boundaries of the Monument (Monument Values) was one of the two significant issues identified during scoping. Significant issues are discussed in greater detail in Section 1.4 of the FEIS. . Please see Section 1.6, Agency Responsibilities (Permits and Approvals), of the FEIS for management direction and for other agency involvement on the various permits, approvals and decisions necessary for continued operations of the Greens Creek Mine. The Forest Service will require KGCMC to take measures to protect the affected resources to the maximum extent possible through conditions in the GPO.

Please see Section 2.2 of the FEIS for detailed discussion of water management, monitoring, mitigation and reclamation associated with all alternatives.

3.5 Several comments emphasized the value of the Admiralty Island National Monument and the commenters concern about impact to the monument.

Please see response 3.1 and 3.4.

Chapter 4 Wetlands

4.1 Page 3-63 references Appendix D, the Jurisdictional Wetlands Survey. Appendix D is the Sensitive Plant Species Survey, Appendix A is the Jurisdictional Wetlands Survey.

The Jurisdictional Wetlands Survey and the Sensitive Plant Species Survey have been removed from Appendices in the FEIS, and are incorporated by reference. These references are in the planning record and available upon request at the Juneau District Office. Wetlands within the project area are discussed in Section 3.9 and summarized in Section 4.6.

4.2 Page 3-64 and 3-67 describes wetland and general plant associations, respectively. The EIS should contain maps identifying these plant complexes.

After discussion with the commenter, it was agreed that the maps in Appendix A, Jurisdictional Wetlands Survey, met this need and no change was needed.

4.3 Page 4-33 should indicate whether proposed activities are covered under an existing nationwide permit. In addition, the EIS states that these wetlands received a "low" value rating in the functions and values analysis partly because of their proximity to existing disturbance. The EIS should discuss the total impairment to wetlands in the cumulative effects section.

The following sentences have been added to Section 4-6 Wetlands:

"Several individual CWA Section 404 permits have been issued for mining operations in the area, including the Tailings Impoundment Area, Permit No. 4-880269. Additional fill in wetlands in connection with this project would be done under this permit or a new permit." issued by the US Army Corps of Engineers. Please see section 1.6 of the FEIS for Corps of Engineers jurisdictional responsibilities.

The cumulative impacts section has been modified to include a discussion of the total impairment to wetlands.

4.4 Page 4-34 states that activity associated with the proposed stormwater pond system would fill approximately 300 linear feet of high value riparian wetland. The EIS should describe this high value wetland in the text description for other alternatives and show it on maps.

The text and wetlands maps in Chapter 4 have been clarified to more precisely locate this stream and impacts to the associated high value riparian wetland.

4.5 The handling of Alternative A in Table 2-5, page 2-39, is confusing insofar as it characterizes zero wetlands acreage impacts as "minor" rather than "none" and assigns an impact measure of "negligible" to other elements (e.g., birds, subsistence, etc.) when Alternative A is supposed to represent no change from the status quo.

Please see Chapter 2, Section 2.4.1. Alternative A description reads: "The "No Action" alternative would not modify the existing general plan of operations to permit any expansion of the tailings disposal facility. Kennecott Greens Creek Mining Company would continue its present method of generating whole tailings. The tailings would be placed without chemical or biological additives other than those currently allowed by the State of Alaska solid waste permit. The tailings pile would be limited to 29 acres in size. Under the current permit the existing tailings facility has space for about 600,000 additional tons of tailings. At current rate of production, KGCMC would run out of room for tailings surface disposal in roughly 2 years without a permitted expansion of the pile."

Alternative A, the no action alternative, provides a status quo basis for comparison of the action alternatives. Also, please see Chapter 4, Section 4.6 discussion of impacts to wetlands under Alternative A.

Chapter 5 Wildlife

5.1 As an example the DEIS states that brown bear, in the area, have become habituated to mine activity. See DEIS at 3-71. Additionally mine facilities do occupy bear habitat. How does one know what the implications are to the local bear population when measured against a non-existent management standard that should be based on ANILCA and the 1997 Tongass plan direction for the National Monument? This is all complicated by the very real possibility of long-term degradation of water quality.

Section 3.11.1 of the FEIS discusses bear habitat and populations within the project area. It also discusses a 1981-1989 ADF&G bear study, which concluded that it did not appear that the home ranges and seasonal distribution of adult brown bears were substantially influenced in the short term, with the exception of denning distribution. Their observations suggested that brown bears, particularly young bears were becoming habituated to aircraft and vehicle noise associated with the mine.

All contact water is isolated and collected for treatment under all alternatives. All discharged water must meet Alaska Water Quality Standards. There is no evidence to suggest a possibility of degradation of long-term water quality. See Sections 4.5 and 4.17 of the FEIS.

5.2 This leaves the Forest Service, mine operator, other agencies and the public with no idea what the bear management objectives are and what monitoring and mitigation steps are required. Under this scenario the only way to know if this project has adversely impacted the bears is to examine the population after final mine reclamation and after some years (perhaps hundreds of years) of water quality monitoring. And then it is too late.

Please see Response 5.1.

5.3 Page 3-74 should describe the general population trend of Sitka black-tailed deer and waterfowl and shorebirds. The EIS should also state if the increase in deer accidents in the Year 2000 was attributable to an increase in the deer population.

Snow is the main factor affecting deer population on northern Admiralty Island. Since the heavy snows contributed to high mortality rates during the winter of 1999, the deer population in the study area has been rebuilding. In the Seymour Canal and northern Admiralty Island areas, the 2001 harvest increased 40% over 2000. ADF&G does not have data on population trends for waterfowl and shorebirds in the area. The increase in car/deer accidents was not statistically large enough to support conclusions on whether or not the increase was linked to a deer population increase.

5.4 Page 3-76 should spell out the Red-br. Sapsucker.

This has been corrected.

5.5 Pages 3-78 and 3-80 both contain section on Marine Mammals and describe species listed under the Endangered Species Act. The EIS should consolidate its Marine Mammal section and identify species protected under the Marine Mammal Protection Act.

After discussion with the commenter, it was agreed that it is proper to treat marine mammals that are Listed, Threatened, or Candidate species under the Endangered Species Act in a separate section from other marine mammals.

5.6 Pages 3-80 and 3-81 state that staff have observed few Steller sea lions transiting near the mouth and within Hawk Inlet every year but paragraph 4 on page 3-85 states that when the salmon are running, sea lions are abundant inside the Inlet. The EIS should reconcile these statements.

The sentence in question has been edited accordingly, 'few' removed before 'Steller sea lions…'

5.7 Page 4-50 should also include the Marine Mammal Protection Act as part of Section 4.16.3.

This information has been added.

5.8 The last sentence on page 4-42 indicates that in the context of Threatened and Endangered Species, possible impacts from ore barges or ship traffic were considered. While we agree with the conclusion that Steller sea lions and humpback whales are not adversely affected by mine related ship traffic, the focus of the discussion in section 4.9 should be on effects of the tailings expansion and thus the second sentence in the carryover paragraph spanning pages 4-42 and 4-43 should be stricken from the FEIS as unnecessarily covering activities beyond the context of the EIS scope.

The sentence in question reads, "No activity associated with any of the alternatives would constitute harassment or a taking under the Endangered

Species Act". The Forest Service believes that finding is important to the conclusions of this section.

5.9 Figure 3-24 shows the locations of documented bald eagle nests based on 1970-1979 information. More recent information is available on bald eagle nest locations at Hawk Inlet. We recommend that the most current bald eagle nest location information, as shown in the enclosed topographic map (Attachment 3), be included in the Final EIS.

Figure has been updated and renumbered to Figure 3-25.

Chapter 6 Fish

6.1 Page 3-95, Section 3.13.6 is entitled "Summary of Freshwater Environment" but does not discuss Essential Fish Habitat, the subject of Section 3.13. Subsection 3.13.6 should summarize Essential Fish Habitat (EFH) in both marine and freshwater environments.

Section 3.14. has been rewritten to be a "Essential Fish Habitat and Habitat Areas of Particular Concern" This section is part of the summary of a more detailed technical paper (Ridgway 2003) that has been provided to NMFS and is in the planning record.

6.2 Table 3-13 lists Greens Creek twice and Zinc Creek three times with the same species occurrence and abundance information. We recommend that the reiteration of information be reconciled in the Final EIS.

Table 3-13 has been clarified to minimize confusion. In order to present details on marine and freshwater habitat, as well as EFH-specific information, a detailed technical paper (Ridgway 2003) has been provided to NMFS and is in the planning record. Sections 3.13 and Sections 4.11 summarize this paper.

6.3 Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act requires Federal agencies to consult with NMFS on all actions that may adversely affect Essential Fish Habitat (EFH). NMFS is required to make conservation recommendations, which may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects. For the purpose of this DEIS, EFH includes all segments of streams where salmon reside during any period of the year as well as the marine waters and substrates of Hawk Inlet. These areas provide habitat for a number of anadromous and marine species including pink salmon, chum salmon, coho salmon, Dolly Varden char, cutthroat trout, and several species of shrimp, halibut, black cod and king crab.

EFH regulations at 50 CFR Section 600.920(e)(1) enable federal agencies to use existing processes to fulfill consultation and environmental review requirements. The Forest Service has consulted with NMFS under the agreed process of the

EFH Consultation Process (August 25, 2000) to comply with EFH regulations. Through a series of meetings and letters, the Forest Service, NMFS, EPA, ADNR, and KGCMC have agreed to develop an EFH monitoring program that will be adopted as part of the KGCMC GPO. Letters of correspondence pertaining to the consultation are available in the planning record.

EFH documentation and effects assessment are included in the EIS. Additional data has been provided in EIS appendices, and the Forest Service has provided additional technical documentation for NMFS. All data and documentation provided is available in the planning record.

The elements required for an EFH assessment per the USDA FS and NMFS EFH Consultation Process are included in the FEIS and planning record:

1. Description of the proposed action (Chapter 2);
2. Analysis of individual and cumulative effects of the action on EFH, the managed species and associated species, including affected life history stages (Chapter 3 and 4);
3. USDA FS' view regarding effects on EFH (Chapter 4), and;
4. Mitigation measures integrated into each alternative to minimize avoid or mitigate effects on EFH (Chapters 2 and 4).

In order to present details on marine and freshwater habitat, as well as EFH-specific information, a detailed technical paper (Ridgway 2003) has been provided to NMFS and is in the planning record. Sections 3.13 and Section 4.11 summarize this paper. That paper address the issues raised in Comments 6.3 through 6.13.

6.4 Unfortunately, the level of detail provided in the DEIS sections on the marine environment (sections 3.6.6 and 3.6.7 is insufficient for NMFS to make a determination on potential impacts to EFH from the proposed activity. Therefore, NMFS requests that the U.S. Forest Service (USFS) initiate an EFH consultation to fulfill its statutory obligation under the Magnuson-Stevens Act.

See Response 6.3.

6.5 NMFS' main concerns with respect to the mine operations are related to sediment contamination of fish spawning and rearing habitat and the toxic effects of heavy metals and chlorine on aquatic life. Low concentrations of some heavy metals are extremely toxic to plant and animal life, and some metals have the potential to accumulate in greater concentrations as they move through the food chain.

See response 6.3.

6.6 Because many animals residing in soft-bottom benthic communities are important food items in the diets of higher trophic level species, the possible cumulative impacts of mine activities on marine sediment and biota should be evaluated.

See Response 6.3

6.7 During review of the initial EIS for operation of the Greens Creek Mine in 1982, NMFS recommended developing a monitoring program designed to detect changes in the quality of habitat for resident and migratory organisms associated with Hawk Inlet and its freshwater tributaries. This monitoring program included sampling of intertidal and subtidal bottom sediments, the corresponding biota, and the water column for heavy metal concentrations. NMFS' recommendations were included in the marine monitoring program required under the Greens Creek NPDES permit, which requires quarterly water column monitoring, bi-annual sediment sampling, and semi-annual testing of tissues from *Nepthys procera, Nereis spp,* and *Mytilus edulis*.

This biomonitoring program co-designed by NMFS was described in Chapter 3.

6.8 Given the existence of an ongoing marine monitoring program, quantitative information should be provided in the DEIS regarding marine water quality or heavy metal concentrations in seafloor sediments and biota. Most of the information provided in Sections 3.6.6 (Marine Water Quality) and 3.6.7 (Metal Concentrations in Seafloor Sediments and Biological Tissues) is presented in qualitative terms indicating that some metals were found in "generally high" levels prior to mine operations and some metals were "significantly higher" after mine operations. This level of detail is insufficient for NMFS to determine whether increases in metal concentrations as a result of mine operations pose a risk to living marine resources and EFH. To adequately assess the impacts of mine operations and proposed changes in mine operations on marine resources and EFH, NMFS requires data on the concentrations of metals measured, the timeframe over which sampling occurred, sampling frequency, and analysis of trends in the data over time.

See Response 6.3

6.9 Because of the lack of sufficient data in the DEIS, NMFS cannot agree with the conclusion in Section 4.10 (Essential Fish Habitat) that "no discernable effects are expected on marine habitats, subtidal substrata and biota, benthic (sea bottom) habitats in the project area, intertidal sands, submerged sill habitats, kelp habitats, rocky habitats, or freshwater fish habitats, thus no impact on EFH is expected." Although data or information may exist elsewhere to substantiate this conclusion, it is not supported by data or information provided in the DEIS.

Additional data has been added to marine, freshwater and EFH sections throughout Chapter 3 and Chapter 4, Section 4.11. See Response 6.3.

6.10 NMFS 21. Page 3-93, Section 3.13.4 (Freshwater and Salmon Habitat: Original Conditions). The final sentence in the first paragraph states "(a)lthough few of these systems will be affected by any alternative of the proposed action, (the exception being Tributary Creek tributary to Zinc Creek), salmon spawning in any of these streams will migrate through Hawk Inlet which does have the potential to be affected…". This statement appears to contradict the assertion made in Section 4.10 that "(n)o discernible effects are expected on marine life, phytoplankton, marine fish or shellfish, salmon, or Hawk Inlet area fisheries."

This conflict has been reconciled and discussion regarding the likely degree of impact. See Response 6.3.

6.11 NMFS 22. Page 4-15, Section 4.5.1 states (t)here would be negligible adverse effects if tailings effluent is discharged directly to marine waters in Hawk Inlet without treatment." This statement is not supported by data or information presented in the DEIS. Although the water quality model indicates that allowable discharge levels under the existing NPDES permit will not be exceeded, the results from the water quality model do not take into account potential changes, if any, in heavy metals concentrations in marine habitats and biota. Because the DEIS does not present the results of the monitoring program for assessing heavy metal concentrations in marine sediment and biota, a conclusion based on the information presented in that an impact to these resources has not occurred and will not occur in the future is not possible.

See Response 6.3.

6.12 NMFS 24. In conclusion, NMFS is concerned with the potential for changes in the quality of habitat for resident and migratory organisms associated with Hawk Inlet and its freshwater tributaries due to accumulation of heavy metals from mine operations. The Final Environmental Impact Statement should include analysis of the data that have been collected from sampling of intertidal and subtidal bottom sediments, the corresponding biota, and the water column for heavy metal concentrations. This analysis should be of sufficient detail to support a determination regarding potential impacts to EFH and associated species, as well as any appropriate mitigation measures.

See Response 6.3.
Mitigation measures to control routing and separation of contact and non-contact water, layered cover over tailings piles, earthen berm construction and numerous other measures to reduce or minimize potential impacts are described throughout the project descriptions in Chapter 2. A discussion of mitigation measures, which will avoid or minimize impacts to EFH has been added to Section 4.11 of the FEIS.

6.13 NMFS 25. The USFS should initiate an EFH consultation with NMFS as required by the Magnuson-Stevens Act. For additional information on EFH consultation procedures, please contact Katharine Miller with the NMFS Alaska Region at (907) 586-7643.

See response 6.3

6.14 The marine ecosystem surrounding Admiralty Island National Monument is home to myriads of humpback whales, Steller sea lions, orcas, seabird colonies and a host of other species that attract millions of visitors from all over the world. This national treasure is not the place to release toxic substances into the marine environment. I am very concerned about the impacts of the proposed increase of persistent toxins into the waters that nourish the fish I eat. It would be irresponsible of the U.S. Forest Service to allow untested experimental pollution control techniques on Admiralty Island. Have the proposed pollution control techniques been used successfully elsewhere?

Yes. All systems and techniques considered under all alternatives have been used successfully at other mines.

6.15 Page 4-27, Table 4-4. These tables are repeats of tables on Page 4-26.

The referenced Tables have been corrected in the FEIS.

Chapter 7 Bioaccumulation

7.1 Page 4-10 identifies the need for a monitoring program to measure metals uptake by wetland communities and stream sediments, and bioaccumulation. The EIS should also identify follow-up actions for contingencies that occur and are detected by the monitoring plan.

The sentence referenced lists water quality concerns raised by commenters during scoping. Sections 2.6 through 2.13 of the Waste Management Permit (Appendix D of the FEIS) specify visual, groundwater, surface water, leachate, biological, and post closure monitoring requirements, and discuss follow-up actions which may be triggered by monitoring results.

7.2 Figure 3.9 in the Draft EIS is not the figure that has the sampling locations from the RTI investigation (as noted in Pages 3-15); this information is in Figure 3.6. This discrepancy needs to be corrected in the Final EIS. Some of the sampling stations appear similar to sample collection points selected for 1987 and 1997 FWS Hawk Inlet studies. Enclosure 2 summarizes the results from the 1987 and 1997 studies; FWS representatives are available to work with you to integrate these data into your analyses.

The reference to Figure 3-6 is correct in the FEIS. Data collection points were renamed during the studies, which created confusion. We have corrected this in the FEIS.

7.3 NMFS 16. The paragraph on page 3-16 appears to indicate that tissue sampling occurred at three sites (S-1, S-2, and S-3), but the legend to the map in figure 3-6 indicates that sites S-1 and S-2 were sediment sampling sites and sites 1, 2, and 3 were bioaccumulation sampling sites. No S-3 is shown in this figure**.**

The text was corrected to reflect two sites, S-1 and S-2 are sediment sampling sites, and sites 1, 2, and 3 (Figure 3-6) are tissue sampling sites.

Chapter 8 Oceanography

8.1 Page 3-83 should define seafloor features.

A map showing the marine habitats of Hawk Inlet has been added to Chapter 3 of the FEIS.

8.2 NMFS 11. For inorganic nutrients, the document contains only a qualitative statement that "concentrations of inorganic nutrients are comparable to those at Auke Bay, near Juneau." No information is provided on what these concentrations are, when measurements were taken to determine these concentrations, and whether any changes in these concentrations have changed over time.

No data has been found for Hawk Inlet. This paragraph describing nutrients was stricken. Data for Auke Bay nutrients has been provided directly to NMFS.

8.3 Section 3.6.7 Metal Concentrations in Sea Floor Sediments and Biological Tissues: The third paragraph contains several statements that we believe are vague and qualitative. We suggest that specific metals and concentrations be identified, rather than "several metals," "generally high," and "some levels." Without specific information, the background conditions and the effects of the mining expansion on trace metals in sediment and tissues of organisms sampled cannot be evaluated.

See Response 6.3

8.4 NMFS 12. Likewise, this section indicates that lead concentrations "vary, with location, from below detection limits to near acute levels" but does not provide specific data on what the concentrations are at specific location or during what period of time the data were collected. NMFS recommends that this section contain information on the marine water quality sampling program including the parameters being sampled, the frequency of sampling, and a summary of sampling results with both baseline data and data collected since mining operations commenced.

See Response 6.3

8.5 NMFS 13. Section 3.6.7 states that studies have “documented the metal concentrations in seafloor sediment and seafloor creature tissues during the mine’s pre-operational, operational and temporary closure (post operational) periods” and that the “results of these studies are useful for ascertaining natural metal levels and for determining whether mine operations caused any increase above the natural metal levels and for determining whether mine operations caused any increase above the natural levels for metal in sediments and tissue of marine organisms sampled.” Unfortunately, this section does not provide the quantitative results of these studies. Instead, it discusses “ results in qualitative terms indicating that some metals were found in “generally high” levels prior to mine operations and some metals were “significantly higher” after mine operations. This level of detail is not sufficient for determining whether increases in metal concentrations as a result of mine operations pose risks to marine resources. To adequately assess the impacts of mine operation and proposed changes in mine operations on marine resources, NMFS recommends that this section provide the quantitative concentrations of metals measured, the timeframe over which sampling occurred, sampling frequency, and trends in the data.

See Response 6.3. Whereas the quantitative results, timeframe and frequency have been provided, the data does not adequately support trend analysis.

8.6 NMFS 14. Section 3.6.7 also states that “polychaetes worms were sampled as indicators of heavy metals accumulating in marine life in Hawk Inlet” and that concentrations of lead and arsenic increased after mine operations, but no information is provided on the frequency of sampling or the timeframe for the sampling results. No data are provided for the arsenic increases. Specific data are only provided for lead. No information is provided about when the specific data were collected or whether lead levels have continued to increase. NMFS recommends that this section provide current quantitative data from the tissue sampling including frequency of sampling, a comparison of Baseline and subsequent results and analysis of any trends in the data.

See Response 6.3.

8.7 NMFS 15. Section 3.6.7 needs a discussion of the extent to which mine operations are responsible for increases in metal concentrations in sediments and tissues so that the alternatives being considered can be evaluated for potential impacts to marine resources.

See Response 6.3

8.8 Page 3-89 references Section 3.1 (Oceanography). Section 3.6.7 is Oceanography not Section 3.1 (Location). The final EIS should correct this.

This has been corrected in the FEIS.

Chapter 9 Socioeconomic

9.1 Page 4-5 discusses connected actions (past, present, and reasonably foreseeable future). The EIS should discuss the possibility of a shutdown caused by historically low zinc prices.

Section 2.2.5 has been renamed "Temporary Closure and Reclamation After Closure" and information added to the FEIS that further explains temporary suspension of operations.

9.2 Page 4-8 should discuss who would view the altered landscape and the impact of altered views on the viewers. For example, the EIS should state if the view would affect the attractiveness of the area to cruise liner passengers and people on guided tours.

The Visual Quality section conforms to Forest Service Visual Quality Objectives for the area. See clarifications in Chapter 3, Section 3.5, and Chapter 4, Section 4.4. The FEIS discusses views from small boats and ferry passengers. This area is not subject to a VQO for cruise ship passengers and people on guided tours.

9.3 Page 4-45 contains a section on the socio-economic impact. The EIS should state the effect on recreational opportunities, if any exist, from expanding the mine and the tailings pile.

This information was provided in the DEIS on pages 4-44 and 45 in Section 4.13 Recreation. It is also in the FEIS, Chapter 4, Section 4.15.

9.4 I am aware of the economic benefits that the Greens Creek mine provides to the local economy as described in the Draft EIS. However, the Draft EIS does not describe where the profits go. You mentioned at the "public hearing" in Juneau that the mine is actually owned by a multinational corporation. In addition to knowing how much revenue and how many jobs the mine provides for the Juneau area, how much of the profits from the mine leave Alaska? What percent of the mine's profits goes to Alaskans and what percent goes to people that live in foreign countries? How much money from the mine leaves the U.S.?

The FEIS, in Section 4.15, discusses the direct, indirect and cumulative impacts of the project on the local economy. The ultimate distribution of corporate profits derived from the operation of the Greens Creek mine is unknown and outside the scope of this EIS.

9.5 At the Juneau "public hearing" you described that the mine will have to close anyway in 10-12 years. I understand the difficulty in making a decision that may take away jobs. However, this decision is not yours to make. The jobs provided by the mine are not sustainable. Whether in two years or twelve, the people currently employed by the mine will have no job. The real choice here is whether to close the mine now and have a minor Superfund site or wait twelve years and have one of the largest environmental disasters in Alaska.

The projected mine life, based on known and anticipated reserves is 24 additional years. There is no evidence to suggest that the project will become a Super Fund site. See section 4.15 for discussion of socioeconomic effects on the local economy.

9.6 The following statement is contradicted by information presented later in the DEIS: "The Greens Creek Mine supports an annual payroll of approximately $26 million and employs a workforce of approximately 265 individuals—120 in mining and underground support, 60 in the mill, 55 in surface support, and 30 in administration." (DEIS, p. 1-2, emphasis added) However, in Section 4.14 Socioeconomics, it is stated: The socioeconomic effects, measured as prolonged benefits, could include (for example) annual direct payroll of $19 million. (DEIS, p. 4-45, emphasis added) The $19 million figure for an annual direct payroll is repeated again in Table 4-6. Recommendation: Since the information in Section 1 is often copied to other documents, the correct direct payroll information should be presented there.

The correct information ($26 million) has been displayed throughout the FEIS.

9.7 Two commenters expressed that extending the life of the Greens Creek mine is important to providing highly paid jobs for people in northern Southeast Alaska and for enhancing its economy and social structure.

Comment noted. This will be considered in the decision process leading to the ROD.

9.8 The operation of the mine already has been interrupted due to world markets; therefore, it is important that any requirements placed on the management of the tailings be flexible and low in cost so that the mine can operate on as full time a basis as possible.

Comment noted. It will be considered in the decision process leading to the ROD.

Chapter 10 EIS Process

10.1 The draft EIS does not contain a summary as required by 40 CFR 1502.12. The final EIS should include a summary.

A summary is included in the FEIS, as required.

10.2 Pages 3-1 and 3-2 list issues. We recommend that the EIS list issues in order of importance, from most important to least important.

After discussion with the commenter, it was agreed to leave issues listed in the order in which they are addressed in the EIS.

10.3 Page 4-21 references Appendixes B for the ADEC permit. Appendix F contains the ADEC permit - not Appendix B. The final EIS should correct this.

The Appendix references have been corrected in the FEIS. The *ADEC 2002 Draft Waste Management Permit* is now Appendix D.

10.4 Page 1-1 explains the mining process - ore concentrate would be trucked approximately nine miles to the Hawk Inlet port at the Cannery, etc. The EIS should describe these connected actions and the additional impacts from continuing to mine ore reserves beyond those described in earlier NEPA documents.

The Forest Service views these actions as cumulative impacts. The Cumulative Impacts Section has been rewritten and expanded. The rewrite discusses the cumulative impacts from continuing to mine, process, truck, and ship ore.

10.5 Page 1-2 states that the remaining storage is estimated to last roughly 2 years versus 4 years on page 3-4 of the PDEIS. Please explain why.

This EIS process has taken over two years during which two years of capacity have filled.

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10.6 Page 1-5 states that permitting this expansion would require modifying the existing lease. Is this a decision to be made based on information in this EIS? We recommend that the EIS succinctly identify all the decisions to be made using a bulleted format.

A bulleted list of all decisions to be based on the information in the DEIS has been added to the FEIS. See Chapter 1, Section 1.6 Agencies and Responsibilities, Permits and Approvals.

10.7 The Forest Service analyzed only alternatives that would modify the GPO to permit expansion of the tailings disposal facility. These alternatives fail to respond to the significant new information regarding the existence of, and impacts to monument values from, acid generating material in the waste rock and construction rock. In addition, the alternatives analysis fails to provide a sufficient range of alternatives or a detailed discussion of each alternative.

Chapter 40 of the Code of Federal Regulations (40 CFR), Part 1508.25, states: "Scope consists of the range of actions, alternatives, and impacts to be considered in an environmental impact statement. … ".

40 CFR, Part 1508.25 also states: "To determine the scope of environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of impacts. They include: … Alternatives, which include: 1. No Action Alternative; 2. Other reasonable courses of actions; 3. Mitigation measures (not in the proposed action)." Based on the results of scoping and the determination of issues to be analyzed in detail, a range of reasonable to the proposed action was developed and considered. As established in case law interpreting the National Environmental Policy Act, the phrase "all reasonable alternatives" has not been interpreted to require that an infinite or unreasonable number of alternatives be analyzed, but does require a range of reasonable alternatives be analyzed whether or not they are within Forest Service jurisdiction to implement.

A Memorandum of Understanding (MOU) between the USDA FS, USACOE, EPA, USFWS, ADEC, ADNR, ADF&G, ADGC, CBJ and KGCMC was signed in 2001 to develop this EIS and other related documents, reports and evaluations in connection with the issuance of the federal, state, and local authorizations, leases, and permits necessary for the development, construction, and operation of a new or expanded tailings facility on Admiralty Island. These agencies worked cooperatively to develop the range of alternatives to be considered in the environmental analysis, and the mitigating measures for each alternative.

Please see Section 1.6 of the FEIS for the Agencies responsibilities in considering the potential impacts of the different alternatives considered in this environmental analysis. Also see Section 2.2 of the FEIS for discussion of the various elements common to all alternatives to address the significant issues of Water Quality and Monument Values. Furthermore, each Alternative addresses these significant issues, as well as the other issues identified in the scoping process, in different ways. The Record of Decision (ROD) will identify the selected alternative as well as specific mitigating measures to minimize adverse effects to Admiralty Island National Monument, as well as meeting the purpose and need of the proposed action.

10.8 The DEIS points to uncertainty when discussing both the reclamation plan for the tailings facility and the cumulative impacts analysis. In its discussion of the reclamation methods, the Forest Service states that "the overall tailings acidification risk is considered minimal," but then admits that "the data upon which this analysis is based are variable, and the underlying assumptions have a high degree of uncertainty, making this estimate subject to error." 2003 DEIS at p. 3-51. Similarly, in its discussion of cumulative impacts, the Forest Service states that "there would be very small differences between any of the action alternatives in terms of cumulative effects," but then adds that "[t]hese small differences are greatly overshadowed by the inherent uncertainty in making estimates of past, present, and reasonably foreseeable cumulative effects." 2003 DEIS at p. 4-49.

Many sections of the EIS were clarified or corrected for a better comparison of the alternatives considered. The information in the FEIS provides substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits in order to make a reasoned choice among the alternatives. The information in this EIS is sufficient to address all reasonably foreseeable significant adverse impacts.

See also: Response 10.7

10.9 The draft EIS does not contain a summary as required by 40 CFR 1502.12. The final EIS should include a summary.

A summary is included in the FEIS, as required.

10.10 NEPA requires that when there is incomplete or unavailable information, the Forest Service make clear that such information is lacking. 40 C.F.R. § 1502.22. If the costs of obtaining that information are not exorbitant and the information is "essential to a reasoned choice among alternatives," the agency must include the information in the EIS. 40 C.F.R. § 1502.22(a). However, if the costs of obtaining that information are exorbitant or the means to obtain it are unknown, the agency must include the following within the EIS: (1) A statement that such information is incomplete or unavailable; (2) a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment; (3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment, and (4) the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. 40 C.F.R. § 1502.22(b).

The above citation provided by the commenter is correct. Where information was determined to be incomplete or unavailable, such as the specific details of carbon application in Alternative C and the final design of the reclamation plan, the above guidelines were followed.

10.11 The only limitation in the CEQ regulations is that the information must be "relevant to reasonably foreseeable significant adverse impacts." The regulations specify that "'reasonably foreseeable' includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason." 40 C.F.R. § 1502.22(b).

See Response 10.7 and 10.8.

10.12 The DEIS fails to demonstrate that the Forest Service conducted this analysis as required by NEPA even though it acknowledges incomplete information regarding the reclamation plan for the tailings facility and the cumulative impacts analysis. The incomplete information regarding the reclamation plan for the tailings facility includes the reasonably foreseeable impacts from the acid generating potential in the existing tailings. There is credible scientific evidence that such impacts would have catastrophic consequences on the surface and groundwater within Admiralty Island National Monument if the reclamation plan does not work. Acid mine drainage, once it starts, is almost impossible to stop and lasts forever. It would forever poison the waters of the Greens Creek area or, in the alternative, require expensive water treatment in perpetuity. The Forest Service's confidence in the effectiveness of the cap and in the fact that the overall tailings acidification risk is minimal cannot be reconciled with the Forest Service's uncertainty about the reclamation and closure methods. Rather than addressing the "high degree of uncertainty" regarding the tailings acidification risk, the Forest Service instead focuses on reclamation and monitoring programs to prevent or control acid mine drainage. Even if the probability of occurrence of impacts from acid mine drainage is low, the catastrophic consequences that would flow from the impacts require the Forest Service to go through this type of analysis. The impacts from acid mine drainage meet the "reasonably foreseeable" criteria because they have catastrophic consequences, are clearly supported by credible scientific evidence, are not based on pure conjecture, and are within the rule of reason. Therefore the Forest Service must follow the process set forth in 40 C.F.R. § 1502.22.

See Response 10.7 10.8, and 10.10

All contact water, including leachate from the tailings pile is isolated and collected for treatment under all alternatives. All discharged water must meet Alaska Water Quality Standards. There is no evidence to suggest a possibility of degradation of long-term water quality or catastrophic consequences from any drainage associated with the tailings pile. Sections 4.5, 4.17 of the FEIS discuss hydrology and water management and cumulative effects related to tailings pile drainage.

10.13 Several comments indicated that the Forest Service must complete the same analysis for the cumulative impacts section because the DEIS acknowledges that there is incomplete information relevant to reasonably foreseeable cumulative effects. The Forest Service failed to include a complete cumulative impacts analysis in the DEIS because of the "inherent uncertainty in making estimates of past, present, and reasonably foreseeable cumulative effects." 2003 DEIS at p. 4-49. Similar to the analysis above, such information is "relevant to reasonably foreseeable significant adverse impacts" because the impacts would have catastrophic consequences, are clearly supported by credible scientific evidence, are not based on pure conjecture, and are within the rule of reason. The cumulative effects from the acid generating potential in the tailings, the waste rock, and the construction rock could result in catastrophic, long-term, consequences for Admiralty Island National Monument's values, including fisheries, wildlife, and surface and groundwater quality.

Section 4.17 Cumulative Impacts has been clarified to address comments of this nature.

10.14 The acid-generation potential in the tailings is the main threat to the environment (Shepherd-Miller, 2000, Table 4, p.39). If the cover does not stop all of convective flow of oxygen into both the tailings and waste rock, as is assumed in the modeling, then metals production from the waste could be significant. Contingency measures, should the cover design and/or carbon addition to the tailings not work as modeled, must be identified and discussed as a part of the supplemental draft EIS.

Please refer to Chapter 2, Section 2.2.2 Water Management during Closure and Post-Closure (Reclamation), and Chapter 4, Section 4.5 Hydrology, of the FEIS for detailed discussion and explanation.

10.15 The incomplete information relevant to reasonably foreseeable significant adverse impacts in both of these sections is essential for a reasoned choice among alternatives. Therefore the Forest Service is required to include this information in a supplemental draft EIS.

See Response 10.12.

Additional information has been added to Section 2.2.5 of the FEIS that discusses cap design, performance and potential for breaching the cap.

10.16 The scope of the DEIS is confined to the proposed expansion of the Greens Creek tailings facility. The Forest Service limits the "purpose and need" for the EIS to "consider changes to the 1983 approved Plan of Operations (as amended) for the Greens Creek Mining Company regarding tailings disposal in order to allow for continued operations." The scope is too narrow to meet the requirements of the National Environmental Policy Act (NEPA) and too narrow to address all the environmental threats facing Admiralty Island National Monument from continued operation of the mine.

This EIS was prepared in response to a request by KGCMC to modify their plan of operations to develop additional tailings disposal capacity. It is the prerogative of the Responsible Official to determine the underlying Purpose and Need for the Proposed Action undergoing analysis in this EIS. The range of alternatives must then address significant issues associated with the Proposed Action while meeting the underlying Purpose and Need.

The Record of Decision (ROD) will identify the selected alternative as well as specific mitigating measures to minimize adverse effects to Admiralty Island National Monument, as well as meeting the purpose and need of the proposed action.

See also Response 10.7
The most recent ADEC inspection report (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some sites separate from the tailings pile, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

10.17 Page 1-5 states the purpose and need statement. The proposed action entails changing the plan of operation, not merely considering changing the plan of operation. The purpose and need statement should be written in a more active way.

Please see Response 10.16.

10.18 In Table 2-1, located on page 2-6, we suggest clarification of the cement amendments for the alternatives. The cement quantities shown at the bottom of Table 2-1 represent materials for tailings backfill into the mine and not surface placement of tailings materials, the Table section they appear to occur in when carried over from the first half of Table 2-1 on the previous page (page 2-5).

Table has been clarified and renamed Table 2-3 in the FEIS.

10.19 On page 1-1, there is a confusing logic gap in the last paragraph, in the sentence that says "[b]ecause this soil was placed in the mine's approved waste rock disposal site, the capacity for the disposal of tailings was decreased." This sentence creates confusion about whether the approved waste rock site and the tailings disposal site are in fact the same site. We believe the correct observation is that because the soil was placed in the waste rock disposal site, more waste rock had to go to the tailings facility, thereby reducing capacity available for tails.

This sentence has been clarified in the FEIS.

10.20 The reference on page 1-5 to "known reserves" in the parenthetical in the first paragraph of subsection 1.1 is inconsistent with the explanation at page 1-2 to the effect that it takes the combination of "known reserves" and potential additional mine life from likely discoveries to get to 22 years. The FEIS should clarify that this combination of both "known reserves" and "likely discoveries" together provides the basis for the 22 years.

The parenthetical in Subsection 1.1 has been clarified in the FEIS to read (approximately 22 years at the present rate of production, given known reserves and reasonably foreseeable discoveries).

10.21 The DEIS's discussion at pages 1-13 to 1-14 of the Forest Service's responsibilities and related legal authorities fails to acknowledge Section 503 of the Alaska National Interest Lands Conservation Act (ANILCA), which specifically provides for development of the Greens Creek Mine project.

This section of the FEIS has been modified to reference Section 503 of ANILCA.

10.22 The second paragraph under the "U.S. Army Corps of Engineers" heading includes the sentence: "Activities involving tailings storage, treatment, and disposal are among those requiring a Section 404 permit." This is a misleading statement in that it suggests that as a general proposition the Corps regulates operation of tailings treatment facilities under Section 404 of the Clean Water Act (CWA). Certainly, under Section 404, the Corps regulates wetlands fill operations that may be involved in constructing a tailings treatment facility. The extent to which the Corps can use Section 404 permits to regulate other aspects of a tailings treatment/disposal operation, however, is the subject of litigation. The most recent decision suggests that the Corps' Section 404 authority can include authorizing disposal of mine waste into waters of the U.S., but that arguably is a more narrow function that the DEIS's generalization that "activities involving tailings storage, treatment, and disposal are among those requiring a Section 404 permit."

This paragraph has been clarified in the FEIS to make plain that the initial fill of tailings storage, treatment, and disposal are among those activities requiring a Section 404 permit.

10.23 The carryover paragraph on pages 1-16 to 1-17 describing the Division of Governmental Coordination's (DGC's) responsibilities for implementation of the Alaska Coastal Management Program (ACMP) needs to be updated in the FEIS to reflect the fact that this activity is now a part of the Alaska Department of Natural Resources (DNR's) permitting functions.

This paragraph had been updated in the FEIS.

10.24 Though there is nothing incorrect about the description of the City and Borough of Juneau's (CBJ's) responsibility "for revision of the current Greens Creek Large Mine Permit," at page 1-17, in light of the new CBJ ordinance recently enacted, the EIS would now be more informative if the first sentence went on to say "which can be accomplished through a summary approval process or a permit amendment."

The paragraph has been clarified in the FEIS by the addition of a sentence, "Under the recent revision to CBJ's ordinance, Greens Creek is classified as a rural mine and this revision can be accomplished through a summary approval process or a permit amendment."

10.25 Chapter 1, Page 1-16 describes FWS responsibility under the Endangered Species Act. We recommend that Chapter 1 also include a discussion of FWS' s responsibilities under the Fish and Wildlife Coordination Act (FWCA). The FWCA provides a procedural opportunity for the FWS to coordinate with the U.S. Forest Service and offers means and measures to benefit fish and wildlife resources through mitigation of impacts to water resources and associated fish and wildlife.

Chapter 1, Section 1.6 has been modified in the FEIS with information about the FWS responsibilities under the Fish and Wildlife Coordination Act.

10.26 Several comments indicated that Greens Creek Mine does not meet the standards for mining set forth by Congress and the Forest Service should not authorize an expansion. Instead, it should be actively implementing a plan to address the existing sources of pollution.

The FEIS addresses the standards set forth in Section 503 of ANILCA for the Greens Creek Mine.

10.27 Why did this DEIS go into so terribly much detail? and, 2. Why did this DEIS have to take so long and cost so much? This DEIS addressed an important but none-the-less minor potential problem. The Greens Creek mine site is in a very isolated location where there are few non-mine visitors now and after closure there will continue to be very few visitors. Furthermore, future use of this area of Southeast Alaska will always be very restricted due to the National Monument status of the area. We do not understand the need for this much detail and analysis.

The NEPA requires that any Federal Agency must consider and disclose all potential impacts of actions that it intends to implement or approve. The range of alternatives and depth of analysis is determined by the complexity of the project, potential effects on the environment, and sensitivity of the project area. While both ANILCA and the Forest Plan recognize the existing mineral rights within the project area, they also include direction to protect the natural resources within Admiralty Island National Monument. Following mine closure, this area will be managed as a Non-Wilderness National Monument.

10.28 This DEIS may arguably result in significant additional costs to future DEISs for other mines and other industrial facilities. This is an unwarranted precedent.

See Response 10.27.

10.29 The Greens Creek Mine throughout its history has been a model operation. The mine has operated under very stringent requirements and its performance has been of the highest caliber. The company has gone above and beyond those requirements to minimize any potential for system up set and adverse environmental impact. There is no question that Admiralty Island National Monument is a national treasure and the Greens Creek Mine has proven beyond any doubt that mining can coexist and operate such an area. Thank you for the opportunity to comment on this important issue and we urge that Final EIS be published at the earliest feasible date.

Comment noted.

10.30 Several comments expressed concern over the hundreds of thousand of dollars in water qua1ity violat1ons fines Greens Creek Mine has received during its operations and that the Forest Service is considering an expansion of the tailings facility. All mine wastewater discharge must meet Alaska Water Quality Standards (DEIS4.10). Greens Creek Mine must meet existing standards before future expansion can occur.

The Greens Creek Mine has had no water quality violations related to its tailings discharge since it reopened in 1996. The Forest Service has conducted this EIS under the assumption that all wastewaters discharged are legally required to meet AWQS, and will not approve an alternative that does not. The detailed analysis that has been done shows that the water treatment regime outlined for Alternative C (Chapter 4, Section 4.5 and Appendices A and B) has the potential to yield better long term water quality than the No Action alternative.

10.31 The meeting format was excellent, more exposure to the experts, so better dialogue, recommend this more.

Comment noted.

Chapter 11 Reclamation Plan

11.1 One long standing concern for the reclaimed cover on the waste rock and tailings at Greens Creek is the potential for large trees to grow on the cover, then fall or be blown down, uprooting a portion of the cover and exposing the clay oxygen-barrier layer to desiccation. This concern is addressed in a footnote of the DEIS as follows: "To breach the integrity of the cap, the roots of a fallen tree would have to: Extend through the top layer of 24 inches of growth material (plus any additional thickness that would occur from rotted vegetation in the 100 to 150 years it would take for any hemlock or spruces to grow to full size), extend far enough into the 24 inch compacted clay/gravel layer to disrupt the integrity of this layer when the tree fell. In dry areas where trees have deep tap roots to reach water, such as the Richmond Hill Mine in South Dakota, tree growth on the mine covers has been prohibited because of the potential of blow downs to disrupt the cap. In southeast Alaska the root structures of hemlock and spruce trees are typically very shallow Greens Creek has informally measured the thickness of the root wads of a number of fallen old growth trees in the vicinity of the mine and tailings facility and have not found any that extend to 24 inches in depth, less than the depth of the top layer of the cap. When blow down does occur, the dirt from the root falls back into the hole over the next several years and over time the hole evens with the rest of the forest floor." (DEIS, p. 2-30, footnote 1, emphasis added) While this empirical observation is a start, the potential impacts should the cover be breached are significant. All the water quality modeling, which assumes the oxygen-barrier cover works 100% as designed, would be invalid if the oxygen-barrier layer was breached, or even exposed. Recommendation: A qualified silviculturalist or forest biologist should be employed to verify and/or quantify the potential impacts from tree blow down on the engineered cover.

Comment noted. This comment, as others, will be considered in development of the ROD and approval of the General Plan of Operation. This is also an appropriate comment for the draft DEC Waste Management Permit. That draft permit already contains an extensive section on monitoring, which requires in part, monitoring for:

2.7.1.5 slippage, erosion, cracks, or other damage to the visible portion of a cover system,

2.7.1.6 damage to the structural integrity of a monitoring device, containment or seepage structure, retaining wall, erosion control or diversion structure.

11.2 Section 2.2.3 Concurrent reclamation pg 2-34: Instead of only initiating reclamation planning as parts of the tailings impoundment are available in the next 2-5 years, the Forest Service must require the KGCMC to begin concurrent reclamation of parts of the tailings impoundment as soon as possible to minimize acid mine drainage and metals leaching potentials, and other water quality problems. Recommendation: This requirement should be made an enforceable standard in the Plan of Operation.

The Forest Service will consider this comment during its review and approval of the Plan of Operation. Concurrent reclamation is discussed in Section 2.2.4.

11.3 The Draft Permit includes an updated financial assurance calculation, with a total value of $26,170,000, including the expanded tailings facility, and $1,770,000 more than the $24,400,000 value calculated by Alaska Department of Environmental Conservation (ADEC) in July 2001 for the present permit. Reclamation at the Greens Creek mine is planned to occur both concurrent with operations and after mining and milling have ceased. Concurrent reclamation efforts will take place on specific sites, such as production rock sites and lower portions of the tailings impoundment, as reclamation materials become available and sites are no longer needed. Final reclamation and closure monitoring will begin after mine closure. Physical reclamation tasks such as building removal, recontouring, and revegetation are planned for completion within 5 years of closure. Water treatment facilities are anticipated for use no longer than seven years after closure, and environmental monitoring will be conducted for 30 years under this reclamation plan. (KGCMC 2001) The Greens Creek mine reclamation plan and closure cost estimates were prepared in accordance with standard engineering cost estimation procedures and are consistent with methods commonly used by industry as well as state and federal agencies. Current financial assurances are held by the United States Forest Service (USFS) for the Alaska Department of Environmental Conservation (ADEC) in the amount of $24,400,000 to cover the cost of mine site reclamation and closure, water treatment, as well as monitoring and maintenance of reclamation work, engineered soil covers, and surrounding water quality. The proposed tailings impoundment expansion is estimated to increase the reclamation cost by $1,770,000, which will increase the overall financial assurance amount to $26,170,000 (USFS 2003). Current financial assurance amounts for the Greens Creek mine held by the USFS guarantee reclamation takes place in the event of bankruptcy, or other circumstances where reclamation is not completed by Kennecott Minerals Company and Hecla Mining Company are evaluated in this report. This technical review is based on analysis of the existing reclamation plans and financial assurance cost estimates listed in Kennecott Greens Creek Mining Company General Plan of Operations, Appendix 14, Attachment A, “Detail Reclamation Plan Cost Estimates,” November 15, 2001; and the planned tailings impoundment expansion discussed in USFS Greens Creek Tailings Disposal Draft EIS, Appendix F, ADEC Draft Waste Management Permit, Section 9.1.2, April 2003. CSP 2 has conducted a review of the financial assurance calculation based on the information presented in the KGCMC Reclamation Plan. This evaluation was developed to ensure that the financial assurance amounts held by the USFS for the state of Alaska are adequate to cover the costs of reclamation and closure as required by Alaska statutes and regulations. The state of Alaska is required to obtain financial assurances to ensure that the approved reclamation tasks are completed in the event Kennecott Minerals Company and Hecla Mining Company fail to perform the necessary tasks as outlined in the reclamation plan. Financial assurance estimates calculated in this review were performed in accordance with standard cost estimation procedures and are consistent with methods commonly used by state and federal regulatory agencies. Site-specific reclamation tasks and associated areas of disturbance were developed from the aforementioned financial assurance estimate. Assumptions, reclamation tasks and associated costs used in this estimate are the same as those used in the existing reclamation plan and financial assurance(s), except where noted in the explanations for each scenario. First, the existing financial assurance estimate was replicated (as Scenario 0) in a format that allows for unit costs to be determined for specific reclamation tasks. Next, four scenarios were developed where unit costs, indirect costs, and project timelines were evaluated and varied as described in the following sections. Finally, cash flow worksheets were generated for each scenario. Two-thirds of the way down on page 4-10, the second paragraph states that "[t]he reclamation plan for all alternatives would comply with Appendix 14 of the 1983 Greens Creek FEIS." This is incorrect. The correct reference should be to the current (October 2000) Appendix 14 to the GPO.

Comment noted. These calculations and your recommendations will be considered in the review and approval of the bond for KGCMC.

Please see Appendix D: ADEC Draft Waste Management Permit.

11.4 Two-thirds of the way down on page 4-10, the second paragraph states that "[t]he reclamation plan for all alternatives would comply with Appendix 14 of the 1983 Greens Creek FEIS." This is incorrect. The correct reference should be to the current (October 2000) Appendix 14 to the GPO.

This reference has been corrected in the FEIS. Appendix C of the FEIS now contains the KGCMC GPO Appendix 14.

11.5 The four-layer tailings cap is designed to provide an oxygen barrier that prevents acid-generation of tailings which would adversely affect the three downstream fish-bearing streams. We recommend that the vegetative growth on the cap be maintained at all times to provide erosion control. We believe that monitoring to detect cap erosion should also be required in the site's monitoring plan.

See Response 11.1. The draft DEC Waste Management Permit already contains an extensive section on monitoring, which requires in part, monitoring for:

2.7.1.5 slippage, erosion, cracks, or other damage to the visible portion of a cover system,

2.7.1.6 damage to the structural integrity of a monitoring device, containment or seepage structure, retaining wall, erosion control or diversion structure, and,

2.7.1.7 evidence of death or stress to fish, wildlife, or vegetation caused by the facility.

11.6 Kennecott with its mine plan and accompanying reclamation plan can and will mitigate additional release above what is already occurring by natural processes.

Comment noted.

11.7 It is our understanding that the greatest potential for the creation of acid mine drainage will occur from 50-100 years after the proposed tailing facility is closed. From our review of this DEIS there are no requirements in place to monitor water quality during this critical time period. We believe that a 100-year monitoring program and remediation bond for both the marine waters of Hawk Inlet and Greens Creek proper should be instituted as part of this permit if granted. While constraining the applicant to monitoring of this length and magnitude may appear excessive, it should be deemed a necessity for their undertakings given the time frame in which acid mine drainage is generated, but more importantly because the operation takes place adjacent to both a National Monument/Wilderness Area and essential habitat for brown bears and anadromous fish. Furthermore, it is clear that any expansion of the tailings facility at Greens Creek will result in the expansion of potential for more acid generation and thus increases in monitoring duration and performance bonds are justified.

The duration of the monitoring is set by the Department of Environmental Conservation in its Waste Management Permit. Sections 2.6 through 2.13 of the Waste Management Permit (Appendix D of the FEIS) specify visual, groundwater, surface water, leachate, biological, and post closure monitoring requirements. Prior to cessation of monitoring, KGCMC must demonstrate ".... that all downgradient monitoring stations have been in compliance with Alaska Water Quality Standards (AWQS) for at least 3 years. Additionally, results of monitoring at internal sites must corroborate the finding that water quality downgradient of the facility will not change in the foreseeable future.
DEC retains the right to extend monitoring requirements as long as it is needed.

11.8 Recognition of Options for Quarry Resources - The reduced Tailings Footprint and Lease Boundary changes in Alternative "C" are acceptable as compared to the KGCMC proposal (Alternative "B"), with the recognition and understanding that the elimination of the southern most quarry within the Monument Boundary may cause KGCMC to apply for an additional quarry site in the future, if construction materials become limited from the reduced acreage of the proposal. KGCMC does not expect this problem, but has several experiences of "rock shortages" due to rock suitability issues from past quarry sites. KGCMC will extend quarry site investigations prior to excavations to identify if a problem arises prior to the construction phases and will address additional future quarry leases as needed.

Comment noted.

11.9 Continued Use of Existing Systems for Final Reclamation Purposes. Inclusion of provisions for final reclamation considerations to address the continued use of the outfall line and mixing zones post closure for any of the alternatives should also be addressed within the FEIS document.

This issue is addressed in multiple sections of the FEIS in Chapter 2, as well as in Chapter 4, Section 4.5, as well as in Appendix A, *Hydrology and Geochemistry of the Greens Creek Tailings Facility*.

Chapter 12 Alternatives

12.1 Page 4-1 should state what the life of the mine would be if Alternative A is adopted.

That information is provided in Chapter 1, Background, and Section 1.1 and in Chapter 2, Section 2.2 and throughout many other pertinent sections of the document.

12.2 There should be high environmental standards for this mine due its location in a highly valued National Monument. A new alternative that is based on proven management practices for the expanded waste piles should be added.

Chapter 3, Sections 3.7 and 3.8, and Chapter 4, Section 4.5 and Appendices A and B of this FEIS address acid drainage and increased heavy metals concentrations connected to the tailings pile. Other portions of the mine have been addressed through previous EIS's or EA's as separate NEPA actions. The Alaska Department of Environmental Conservation's Waste Management Permit also addresses these issues for the entire mine. The selected alternative is based on proven technology. Please see the summary of past use of cap design and carbon addition in Response 1.20 and 3.3.

12.3 NEPA requires the Forest Service to "[d]evote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits." 40 C.F.R. § 1502.14(b).

See Response 10.7 and 10.8.

12.4 The Forest Service has failed to describe in sufficient detail the various alternatives. For example, the preferred alternative, Alternative C, provides for a continuous addition of carbon to the tailings during placement, but there is no explanation of how this would be done. Carbon addition to prevent acid formation over the long-term is a new, unproven technique, and there are no examples of it being done successfully in the past. Therefore there is even more need for the Forest Service to describe this alternative in detail.

See response 10.8 and review Appendix B, Sulfate Reduction Monitoring Program.

12.5 In addition, the plans for the preferred alternative are insufficient to determine the risks of significant environmental impacts. Alternative C provides for the use of a post-closure construction of an engineered soil cover on the pile. The DEIS states that "[o]nce the cap is in place, runoff water will not come in contact with tailings." 2003 DEIS at p. 2-29. The Forest Service relies too heavily on the success of the cap. It is unlikely that the effectiveness of the cap can be stated with this degree of certainty. There is a risk that the cap will not work and the result will be significant environmental impacts. The DEIS fails to explain what would happen if the cap failed and what system would be put in place to replace the cap.

All alternatives, including the No Action Alternative depend on the use of the 4 layer engineered cover. Chapter 2, Section 2.2.5 Temporary Closure and Reclamation After Closure describes the cap, the type of soil to be used, and the availability of the soil. Language has been added to describe the availability of drain rock and the effectiveness and cost of the cap. Information about cover performance and consequences of failure has been added to the end of Section 2.2.3. Please see the summary of past use of cap design in Responses 1.20 and 3.3.

12.6 The Forest Service has also failed to rigorously explore all reasonable alternatives. The pyrite reduction alternative was eliminated from detailed study "because of the difficulty of reclamation of the containment cells, technical feasibility (integrity of long term repository), and high costs associated with its development." 2003 DEIS at p. 2-47. However, pyrite reduction has proven to be a reasonable alternative in the past. For example, this technique is presently being used at the Thompson Creek Mine in Idaho, and incorporated by the Forest Service into its operating plan after analysis in an EIS.

See Response 10.7 and 10.8.

Pyrite reduction alternatives were considered in detail and determined to have the potential to cause significant adverse environmental impacts. Please see Chapter 2, Section 2.6 "Alternatives Considered and Eliminated from Detailed Study in the EIS" and Appendix G "Alternative Screening Evaluation".

12.7 Several comments recommend the Forest Service to select the No Action Alternative.

Comment noted.

12.8 As a supporter of wildlife, I urge the Juneau Ranger District of the U.S. Forest Service to deny the Kennecott Corp.'s request to increase its toxic waste dumping capacity in the Greens Creek mine on Admiralty Island.

Comment noted.

12.9 Several commenters voiced support of the DEIS and Alternative C.

Comments noted.

12.10 We also support the Sulfate Reduction Monitoring Plan (SRMP) but urge that the disposition of SRMP not be included in the EIS. The EIS must not pre-judge the conclusion of the SRMP. The mine must have the flexibility to incorporate engineering and economic factors based on the results of the SRMP.

The purpose of the SRMP, as outlined in Appendix B, *Sulfate Reduction Monitoring Program Outline, 2002,* is to determine the amount of carbon needed to fuel sulfate reduction for a requisite time post-closure to ensure water quality in perpetuity. Please see Chapter 2, Section 2.4.3 Alternative C for a summary of the SRMP and Appendix B for a detailed outline.

12.11 Finally, based on the information in the DEIS, Alternative C would have the least impact on freshwater and marine resources during mine operation and after closure. This is the only alternative for which the water quality model indicates that zinc concentrations in the underdrain water will not exceed Alaska Water Quality Standards. This result is significant because zinc is readily bioaccumulated and thus can pose a threat to fish, birds, and marine mammals. In addition, Alternative C would require the least amount of disturbance to wetlands. As a result, NMFS recommends that Alternative C be selected over the proposed alternative (Alternative B).

Alternative C was identified in the DEIS as the preferred alternative and in the ROD as the selected alternative. Discussion to clarify the basis for this has been added to Chapter 2, Section 2.4.

12.12 Several commenters recommended supporting Alternative B. Comments indicated that all reasonable conditions that were addressed in the DEIS, and Alternative B does a comprehensive job of addressing the tailings footprint, effluent discharge, visual impact, impacts on waters of the United States, remediation treatment if required, and the immediate habitat.

Comment noted. This will be considered in the decision process leading to the ROD.

12.13 Alt. B could be improved if it had a smaller foot print to assure that the drainage pattern efficiency gathers effluent and deposits it in Hawk Inlet. However, this should be balanced with having a tailings pile that does not greatly impact the viewshed from Hawk Inlet.

Comment noted. This will be considered in the decision process leading to the ROD.

12.14 Alt. B could be improved if it had some treatment of effluent during the time that the mine is active. It is important that treatment has a negligible impact on the economics of operating the mine and marketing its metals.

All alternatives include the use of containment, collection, and active treatment during the operational life of the mine and for a period of years afterwards.

Chapter 13 Cumulative Impacts

13.1 Page 4-12 discusses a time frame of 50 to 500 years. The EIS should state if changes already occurring due to global climate change have been factored into the models.

The model does not formally account for global climate change. However, since the model is probabilistic, the model has been run for differing rainfall conditions. Therefore, the resultant water quality that would occur in response to climate change is contained within the range of water quality concentrations predicted by the model.

13.2 Page 4-33 should indicate whether proposed activities are covered under an existing nationwide permit. In addition, the EIS states that these wetlands received a "low" value rating in the functions and values analysis partly because of their proximity to existing disturbance. The EIS should discuss the total impairment to wetlands in the cumulative effects section.

See Response 4.3. Cumulative wetland impacts are discussed in the Cumulative Impacts section of Chapter 4 in the FEIS.

13.3 Page 4-48 and 4-49 spends one page of text defining cumulative effects in the context of the project rather than describing them. The information here is insufficient. Recommend that this section be significantly altered to describe the effect on resources of concern over time and space. Focus on how water quality, monument values, and wetlands have been impacted over time due to various activities.

The Cumulative Impacts Section (4.17) in the FEIS has been clarified.

13.4 Page 4-51 section 4.16.4 describes future actions not future cumulative impacts. The little effects' analysis focuses on socioeconomic effects. This and other cumulative effects pieces should be developed around resources rather than activities and focus on the environmental aspects.

The Cumulative Impacts Section (4.17) in the FEIS has been clarified.

13.5 The DEIS fails to recognize any significant risk of harm to the environment. The cumulative impacts analysis not only fails to address the significant risk of harm to the environment from the expansion of the tailings facility, but also fails to recognize the risk of that harm together with the risks of acid mine drainage from the waste rock and construction rock.

The two significant issues identified during the scoping process include: Water Quality and Monument Values. The Forest Service has recognized the potential for environmental harm from the mining activities, and addresses these through the KGCMC GPO requirements, as well as mitigating measures described in this EIS. Please see Section 2.2, Elements common to all alternatives, which addresses many environmental protection measures. Section 4.17 Cumulative Impacts has been clarified to better explain the past, present, and reasonably foreseeable future impacts related to the tailings pile. All effluent discharged from the tailings pile, under all alternatives considered, must meet the AWQS.

13.6 NEPA requires that agencies consider cumulative impacts in an EIS. 40 C.F.R. § 1508.25. Cumulative impact is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions." 40 C.F.R. § 1508.7.

The Cumulative Impacts Section (4.17) in the FEIS has been clarified.

13.7 The Forest Service asserts that "[p]ast, present, and reasonably foreseeable future impacts included in these analyses are not limited to tailings disposal impacts." 2003 DEIS at p. 4-5, 4-48. Similarly, the Forest Service asserts that the scope for the analysis of cumulative impacts includes identifying "potential effects of the expansion of the tailings pile and attendant extended life of the Greens Creek mine that may occur on the natural resources and human environment." 2003 DEIS at p. 4-49. Again, in the Cumulative Effects by Resource section, the Forest Service states that its analysis includes "the cumulative effects of past mining operations." 2003 DEIS at p. 4-51.

The Cumulative Impacts Section (4.17) in the FEIS has been clarified.

13.8 However, contrary to these assertions, a review of the potential impacts on the resources in the Greens Creek mine area reveals no discussion of reasonably foreseeable cumulative impacts from the waste rock or construction rock. It is already known that there is significant acid generating potential not only in the tailings, but also in the waste rock and construction rock. The increased production associated with expansion of the tailings facility will also result in increased waste rock with significant acid drainage potential. Yet the Forest Service fails to address this significant risk in its cumulative impacts analysis. For example, the entire discussion of hydrology in Chapter 4 reveals no consideration of the risk that acid mine drainage from the waste rock could exacerbate impacts from the tailings. 2003 DEIS at pp. 4-10 to 4-32.

The most recent ADEC inspection report (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

13.9 At a very minimum, the Forest Service is required to recognize that the acid generating potential in the waste rock and construction rock magnifies the cumulative impacts associated with expansion of the tailings facility. The DEIS cumulative impacts section must include an analysis of impacts from waste rock and construction sites on each resource in the Greens Creek mine area and Monument values.

Please see Responses 2.1 and 13.7, The most recent ADEC inspection report (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

Chapter 14 Non-technical Comments

14.1 1304 copies of Form Letter A were received; 55 letters contained additional comments, revisions, or commentary. Below are selections of these comments germane to the Greens Creek DEIS.

14.2 Stop poisoning bears.

Please see Sections 3.11 and 4.8 of the FEIS.

14.3 If the bears are killed and the area damaged it will deter tourists like myself as well and hurt the economy of the local people just as surely as the closing of the plant will.

Please see Sections 3.11 and 4.8 of the FEIS.

14.4 I urge you to support this project, and reject the FEAR that the Mineral Policy Center is trying to pass off as science.

Comment noted.

14.5 The long term impacts to water, wild salmon and wildlife are likely to be very damaging for many years to come.

Please review Chapter 4, Sections 4.5, 4.8, and 4.11.

14.6 If the Greens Creek Mine cannot or will not come into compliance the Forest Service needs to shut it down! ... They obviously can't manage the waste that is already being discharged so why in the world should they be allowed to double the size of their waste impoundment area?

The Greens Creek Mine has had no water quality violations connected to its tailings discharge since it reopened in 1996. The Forest Service has conducted this EIS under the assumption that all wastewaters discharged are legally required to meet AWQS, and will not approve an alternative that does not. The detailed analysis that has been done shows that the water treatment regime outlined for Alternative C (Read Chapter 4, Section 4.5 and Appendices A and B) has the potential to yield better long term water quality than the No Action alternative.

14.7 I am writing to ask that you enforce the provisions of the Alaska National Interest Lands Conservation Act.

The NEPA requires that any Federal Agency must consider and disclose all potential impacts of actions that it intends to implement or approve. The range of alternatives and depth of analysis is determined by the complexity of the project, potential effects on the environment, and sensitivity of the project area. While both ANILCA and the Forest Plan recognize the existing mineral rights within the project area, they also include direction to protect the natural resources within Admiralty Island National Monument. Following mine closure, this area will be managed as a Non-Wilderness National Monument.

14.8 Instead, it should be actively implementing a plan to address the existing sources of pollution, or to terminate the operation of the mine altogether.

. The Greens Creek Mine has had no water quality violations related to its tailings discharge since it reopened in 1996. The Forest Service has conducted this EIS under the assumption that all wastewaters discharged are legally required to meet AWQS, and will not approve an alternative that does not. The detailed analysis that has been done shows that the water treatment regime outlined for Alternative C (Chapter 4, Section 4.5 and Appendices A and B) has the potential to yield better long term water quality than the No Action alternative.

The most recent ADEC inspection report (See Response 1.82 above) concluded that while there was evidence of localized acidification conditions within some of the sites, ARD is not expressed as sustained flows at any of the sites. The report identified measures either planned or are being taken to address both short and long-term environmental concerns. These actions include removal of material, final cover, in-situ treatment or collection and treatment. The report concluded that the sites are well monitored and controlled by the ongoing KGCMC efforts.

See also Response 10.30

14.9 The Greens Creek Mine should not be expanded until it complies with the Clean Water Act.

Please see Response 14.8 and 10.30

14.10 Polluters should pay for their pollution.

Comment noted.

14.11 No entry

14.12 I would also like to add that I am outraged at recent decisions to reject e-mail and fax comments from the Bush administration. These comments are every bit as important as letters by mail, and I believe they are protected under the Constitution as a right to petition the government.

The USDA FS has accepted all written comments on this document from the public including fax and e-mail comments.

14.13 Please give it the protection it so richly deserves and stop rolling over for George Bush and his queen of the interior Gale Norton. Have some guts and do what's right for a change.

Comment noted.

14.14 The operation should not be allowed to increase the scope of its effects on the natural systems of the island but instead should be gradually phased out of existence.

Comment noted.

14.15 Admiralty Island is a national treasure, supporting the densest population of brown bears and nesting bald eagles in the world. Please give it the protection it so richly deserves.

Comment noted. We agree that Admiralty Island is a national treasure. The Forest Service is dedicated to the protection of Admiralty Island and to the provisions of applicable Acts and Laws. The Forest Plan also has guidelines for the management of wildlife species, including bears and bald eagles.

The pertinent Acts and Laws, as well as Forest Plan direction are discussed in the Summary and Section 1.6 of the FEIS, and include Section 503 of ANILCA and the Greens Creek Land Exchange Act of 1995.

Section 503 of ANILCA provides, in part, that holders of any valid mining claim on public lands located within the boundaries of the Monuments, shall be permitted to carry out activities related to the exercise of rights under such claim in accordance with reasonable regulations promulgated by the Secretary to assure that such activities are compatible, to the maximum extent feasible, with the purposes for which the Monuments were established.

The Greens Creek Land Exchange Act of 1995 granted Greens Creek subsurface rights to 7,500 acres of land immediately adjacent to its patented claims in exchange for 139 acres of private inholdings in the Admiralty Island National Monument and 50 acres of private inholdings in Misty Fiords National Monument. The act specified, upon completion of mining, the exchanged 7,500 acres, as well as all lands yet to be acquired by Kennecott on Admiralty Island, will, after reclamation, revert to the USDA FS and be included in the Admiralty Island National Monument, managed as Non-wilderness National Monument LUD.

Appendix G

Alternative Screening Evaluation, 2002

Baker

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DATE: **June 3, 2002**

TO: Eric Ouderkirk,
Acting Minerals Program Manager

FROM: McKie Campbell, Bill Schafer, Scott Benowitz, Jim Munter,
Baker EIS Team

RE: Greens Creek Tailings Stage II Expansion, EIS Alternative Screening Evaluation

Alternative Screening Evaluation

1.0 Introduction

We have examined the significant issues identified by the Deputy Forest Supervisor and a variety of alternatives/options that might respond to those issues.

Significant issues are those used to formulate alternatives to the Proposed Action or to formulate major mitigation actions. Per the requirements of FSH 1909.15, Section 10.4, Fred S. Salinas, Deputy Forest Supervisor, approved the following two significant issues for use in preparing the Greens Creek Tailings Disposal EIS:

1) **Ensuring the isolation of contact water, generated as a result of continued operations and enlargement of the facility, from groundwater and surface waters.** In the short term, this isolation will be achieved through diversion, integrity of sub layers, lining where appropriate, and treatment. In the long term, this isolation will be achieved through diversion, integrity of sub layers and liners where placed, and capping. Water quality concerns raised during scoping included:
   a) The potential for metals loading or Acid Rock Drainage (ARD) from the tailings pile.
   b) The need for reduction of contaminants in the pile.
   c) Long-term maintenance of surface and groundwater standards.
   d) The effectiveness of proposed methods for control of non-contact water.
   e) The need to add a monitoring program to measure metals uptake by wetland communities.
   f) The potential to increase in stream sediments, and bioaccumulation of metals.

2) **Location of the proposed action in and adjacent to the Admiralty National Monument must be considered.** Because part of the proposed action would occur within the National Monument, impacts to the monument should be considered. Consideration of this issue may require the formulation of an alternative in which the footprint of the proposed development is altered to minimize impacts within the monument boundaries.

Those alternatives that would not meet environmental or technical standards, or fail to provide an obvious advantage to other, more environmentally acceptable options are recommended to be included in Chapter 2 of the EIS as "Considered, but dropped from further consideration." The remaining alternatives would be carried through to the document for further analysis.

Section 2.0 describes the development of these water quality related project alternatives. Section 3.0 describes ratings for each evaluation criterion used in the screening process for alternatives/options that would impact water quality. Section 4.0 describes the screening process and presents the results, including which alternatives/options are retained for detailed analysis.

2.0 Alternatives Development

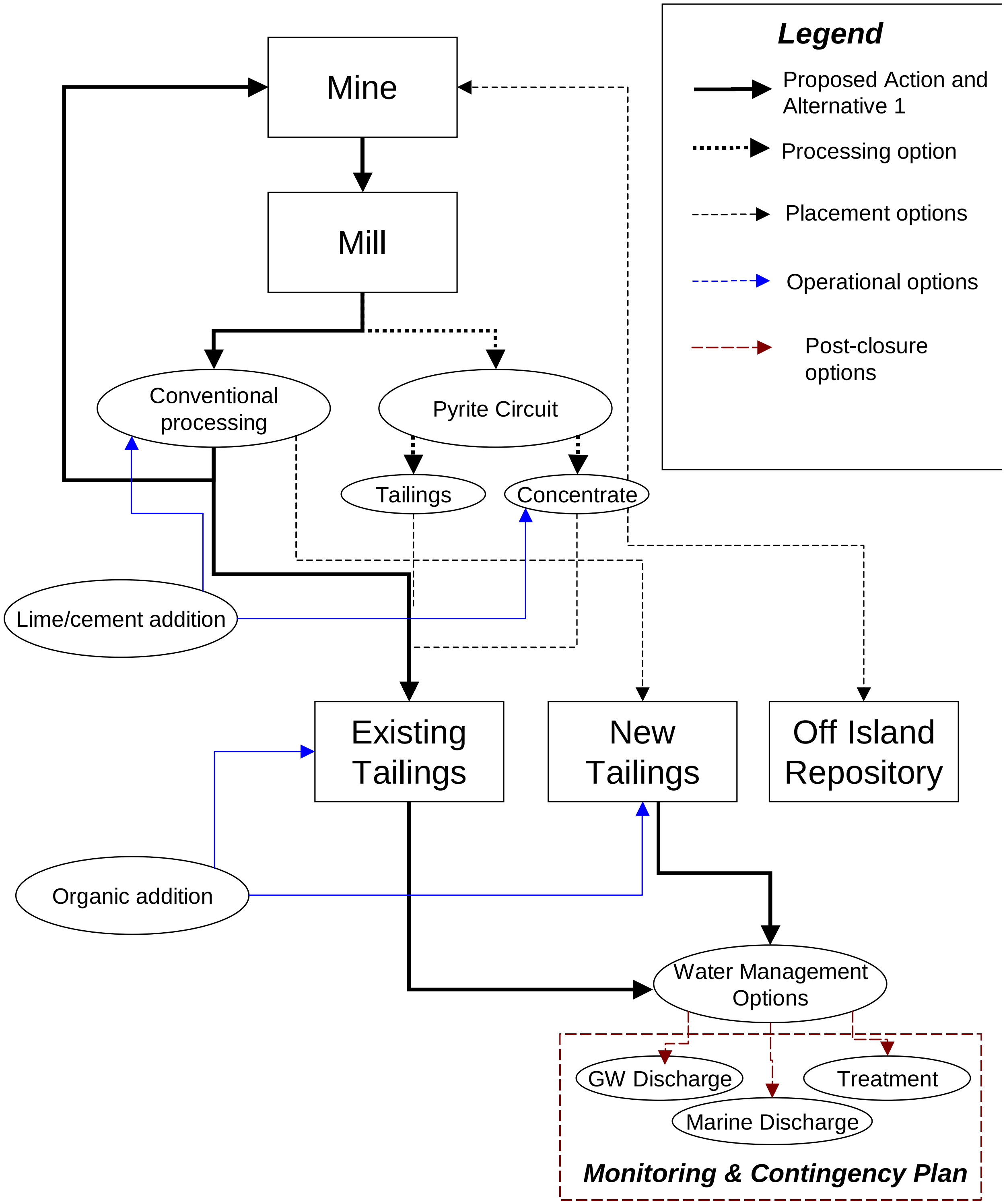
Section 2.1 presents in outline format the alternatives and options that were considered in this screening evaluation. Section 2.2 describes these options in greater detail.

2.1 Alternatives Considered

From information provided by the project proponent, EPA, USFS and USACE; the EIS team's professional knowledge and based on the project's design criteria, the following list of alternatives/options was developed. All of these water quality alternatives/options have been described and considered in the EIS. These are listed immediately below, and are described in the following section (2.2). Figure 1 compares the proposed action to the alternatives/options considered for protecting water quality. The options developed generally relate to processing, tailings placement, operations, or lease boundaries.

- Proposed Action
- Alternative 1 – Same as proposed action except:
    - Tailings pile backed away from slope on southwest side of pile, tailings storage on "East Ridge" area of lease.
    - Southern boundary of the lease area moved north reducing both the lease area and the disturbed area within the Monument by approximately 22 acres
    - Lease area and disturbed area outside the Monument increased by 4.8 acres in northeast corner.
    - Carbon addition to the pile as a veneer if needed.
- Alternative 2 - A pyrite circuit with all pyrite cons stored in containers on pile lease area.

Figure 1. Whole tailings alternatives and Pyrite Reduction Circuit alternatives and options



2.2 Alternatives Description

The alternatives and options that could be considered are described below. The alternatives/options describe tailings produced from the existing milling process (i.e., whole tailings), and as a result of a PRC. The whole tailings process does not separate the pyrite minerals, metals and sulfur into separate materials. A PRC in the mill could consist of pyrite flotation and de-watering, with a potential for ultrafine grinding and cyanide leaching for metal recovery. Approximately 50 percent of the whole tailings material by weight would be a pyrite concentrate that contains most of the pyrite containing minerals, most of the metals and sulfur not collected in the metal concentrate product, and very low amounts of carbonate. The remaining 50 percent would be a material containing approximately 2-3 percent pyrite minerals, the remaining metals and sulfur, and most of the carbonate.

Whole Tailings Alternatives

Proposed Action –

Lease and pile expansion, existing milling process with no additive

KGCMC would continue its present method of generating whole tailings. The tailings would be placed on the expanded pile without chemical or biological additives.

The proposed action involves an 84.5-acre expansion of the boundaries of the existing 56-acre tailings facility to the west, east and south, including additional areas for tailings placement and related infrastructure. **Figure 2** shows the existing 56-acre tailings facility lease area and certain tailings facilities, the proposed 84.5-acre expanded lease area, and the proposed locations for a quarry expansion, two new quarry areas, a reclamation materials storage and borrow area, and a stormwater pond system.

The proposed action includes the following (see **Figure 3**):

- Expansion of the existing Pit 5 quarry to provide construction materials for infrastructure development and construction within the tailings disposal area.
- Development of two new quarries within bedrock ridges within the southern portion of the proposed expanded lease area. These two quarries would be used as a source of construction materials for infrastructure development, and for road construction as needed.
- Construction of a new water management pond system for stormwater storage and treatment.
- Installation of surface water and groundwater controls and diversions, for expansion of the tailings pile.
- Placement of tailings in a "dewatered" state to the maximum elevation of 330 ft above mean sea level (approximately 160 ft above existing ground level), with 3H:1V (horizontal to vertical) external slopes in the same manner currently used. Tailings would be of the same material as is currently being placed.
- Use of the existing Containment Pond No. 6 for containment and storage of sludge materials produced during tailings placement, and eventually for placement of tailings.
- Development of a storage area for excavated reclamation materials (topsoil and organics).

- Development of borrow areas (sand and gravel) within the expanded lease area for infrastructure development and reclamation materials storage.

The tailings disposal facility has been designed to address the following:

- A design basis earthquake having a return period of 1 in 475 years.
- Interception and diversion systems would be designed to control non-contact water around the treatment facility.
- Approved containment structures either manmade or natural (e.g., liner, slurry walls, low permeability deposit) would be used to protect groundwater. Tailings contact water would be collected and treated during operations.
- To meet geotechnical requirements, appropriate phreatic levels would be maintained within the tailings pile by means of drainage infrastructure.
- Non-contact water would continue to be diverted around the tailings and contact water would be treated through the existing permitted discharge system.

Figure 2 Proposed Action Expanded Lease Area

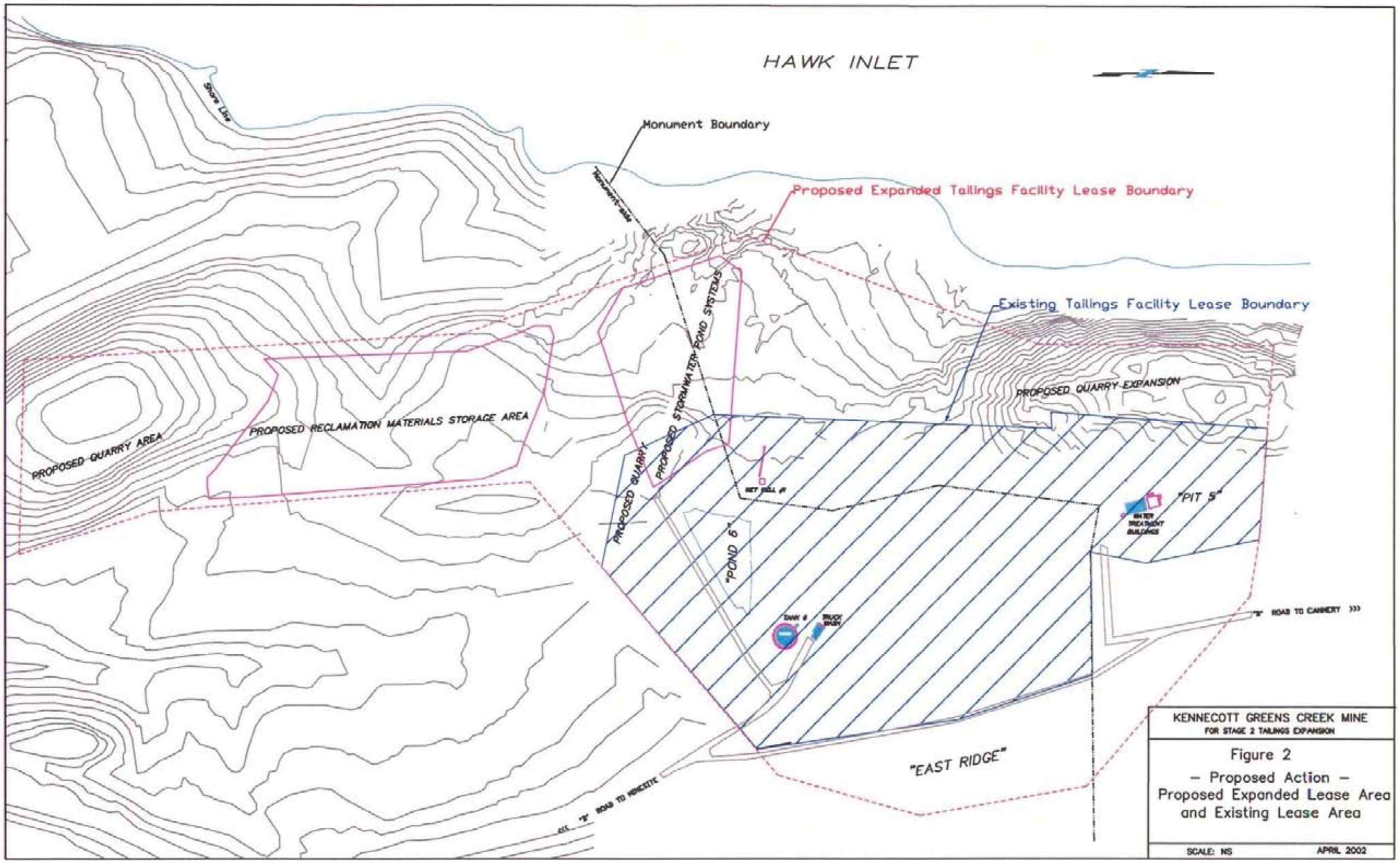
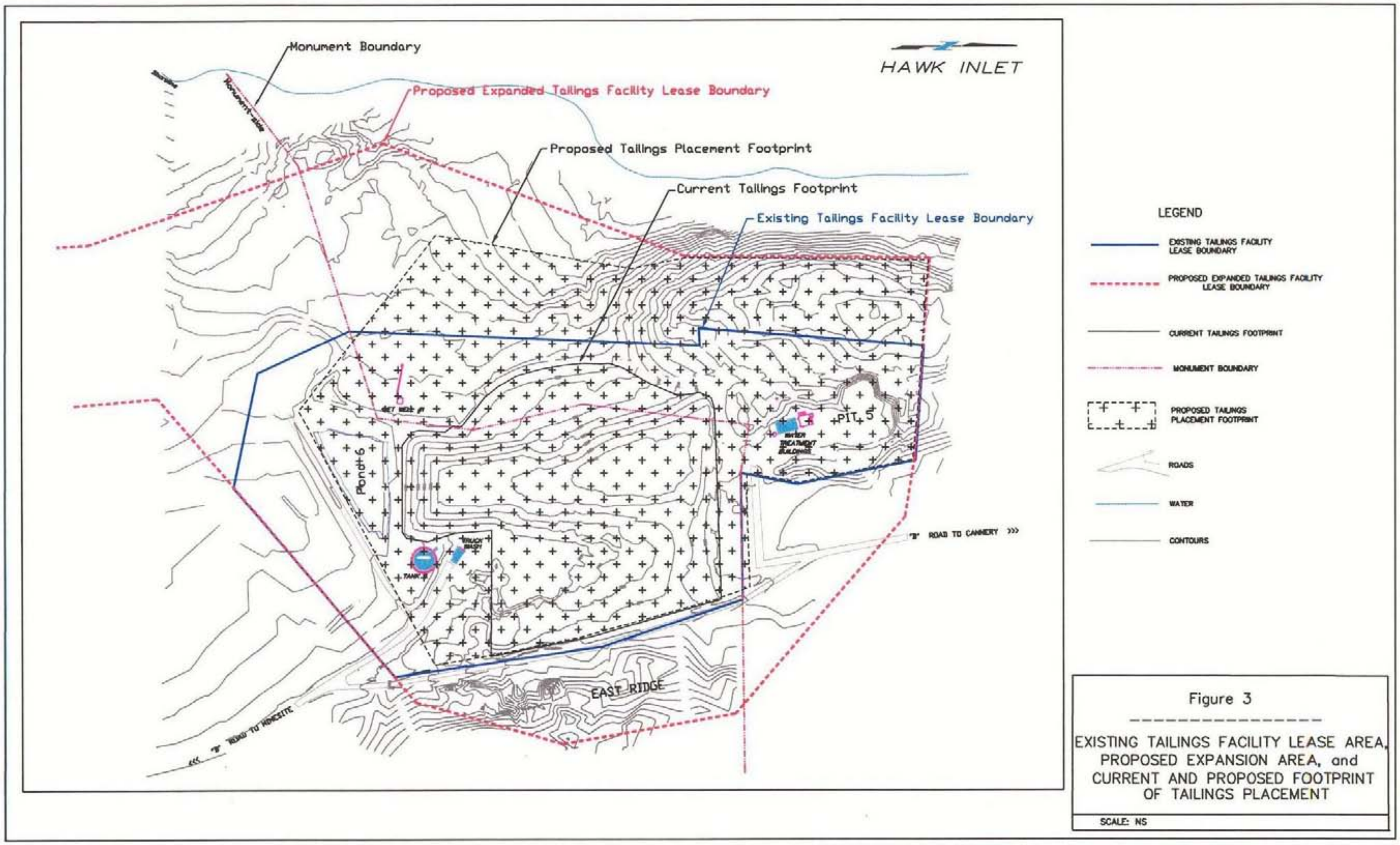


Figure 3 - Proposed Action - Existing Tailings Facility Lease Area, Proposed Expansion Area, and Present and Projected Footprints of Tailings Placement



Alternative 1

Same as proposed action except:

- o Tailings pile backed away from slope on south west side of pile, tailings storage on "East Ridge" area of lease.

Additional engineering studies since the applicant's original proposal have found that the slope break on the western boundary of the proposed lease expansion is steeper than first believed. Accordingly, this alternative would pull back the western boundary of the pile and would expand the pile into the "East Ridge" area of the lease to compensate for the volume reduction. **Figure 4** shows the boundary of the existing 56-acre tailings facility lease, the approximately 23-acre current tailings footprint within that lease, the proposed expanded 84.5-acre tailings facility lease boundary (resulting in an overall proposed lease boundary of 140.5 acres), and the limits of the proposed tailings placement footprint under this alternative. The additional tailings placement footprint would occupy approximately 40 of the proposed 84.5-acre expanded lease area, with the remaining 44.5 acres used for quarry, borrow source, materials storage, and stormwater pond infrastructure needs, as well as for potential long-term tailings disposal needs. The proposed tailings placement footprint is designed to provide tailings storage for the remaining life of the mine (approximately 12-14 years at present rate of production and reserves), plus the East Ridge area would provide storage from development of as yet undiscovered reserves.

- o Southern boundary of the proposed expanded lease area moved north reducing both the lease area and the disturbed area within the Monument by approximately 22 acres.
- o Lease area and disturbed area outside the Monument increased by 4.8 acres in northeast corner.

Options for reducing the footprint of the proposed development within the monument boundaries are limited because of the constraints of the site. Shifting the pile to the east or to the south would move more of the disturbed area into the Monument. Shifting the pile to the west would move portions of the disturbed area out of the Monument, but would place the pile on the slope break down to Hawk Inlet. Such placement could cause problems with containment of contact water and seismic stability of the pile. Shifting the pile to the north would move disturbed area out of the monument, but would move it on top of high value wetlands and make isolation of contact waters from Cannery Creek more difficult.

Greens Creek had considered the idea of a separate tailings disposal area outside the Monument (the 2.2 mile A-road site). The Baker team has previously considered this and other alternative disposal sites outside of the monument In our professional judgment, it is clear that this or any other separate alternative site would greatly increase the environmental impacts in almost every area of concern.

This alternative reduces the disturbed area within the Monument by elimination of the proposed quarry area at the southern end of the lease area and by moving the southern half of the proposed reclamation materials storage area outside of the Monument to the northeast corner just outside the current proposed lease area. **See Figure 5**. The green crosshatched area to the south or left of the map is the area within the Monument we propose be eliminated. The triangle in the northeast or bottom right corner of the map, marked with close red diagonal lines is the area outside the Monument and current proposed lease, that we propose be a new reclamation storage area. The southern boundary of the lease area would move north approximately 1480 feet. This alternative would reduce both the lease area and the disturbed area within the Monument by approximately 22 acres though it would increase the lease area and disturbed area outside the Monument by 4.8 acres. The net change in lease area inside and outside the Monument would be a decrease of 17.2 acres.

- Carbon addition to the pile as a veneer if needed.

KGCMC would continue its present method of generating and storing whole tailings. If a suitable adaptive environmental management plan indicates that a carbon additive will be required in order to achieve reclamation performance criteria, an adaptive environmental management procedure would be developed by KGCMC and the regulatory agencies, and specified in the General Plan of Operation (GPO). A carbon additive would be mixed into the tailings as the final stages of the pile are completed. The result would be a veneer of carbon amended tailings overlying the entire pile. The carbon material, which would consist of organic matter or a combination of organic matter and a liquid carbon source such as ethyl alcohol, would be mixed into the tailings either at the mill or during tailings placement into the pile. The amount of carbon added would be sufficient to support decomposition and sulfate reduction within the surficial tailings. The thickness of the carbon-amended layer would be calculated to provide ample oxygen removal and to cause the chemical precipitation of metal sulfides. If a ten foot thick veneer was amended with 3% organic carbon by weight, a total of 59,220 tons of carbon would be added increasing the tailings area from 61.3 to 62.2 acres (Appendix B).

- **Option 1 -** same as Alternative #1 except with continuous carbon addition.

This option is the same as Alternative 1, except a carbon additive would be mixed into the entire volume of new tailings prior to final compaction on the tailings pile. This could be accomplished by adding organic matter or a liquid carbon source such as ethyl alcohol, and thoroughly mixing this material into the tailings. This could take place in the mill or during the placement procedure on the tailings pile. The amount of carbon added would be sufficient to support two biochemical processes: decomposition and sulfate reduction. Carbon decomposition would consume oxygen so that less sulfide oxidation (and less metals release) occurs within the tailings. Sulfate reduction, which occurs now in the tailings and effectively removes the majority of metals from tailings interstitial water, would continue to reduce metal levels, maintain a neutral pH, and increase alkalinity in tailings seepage. Addition of 1% organic carbon by weight would add 60,00 tons of carbon, increasing the tailings area from 61.3 to 62.2 acres (Appendix B).

- **Option 2** - same as Alternative #1 except with carbonate addition as a veneer if needed

This option is the same as Alternative 1, except a carbonate additive would be mixed into the tailings (if needed) as the final stages of the pile are completed. If a suitable adaptive environmental management plan indicates that a carbonate additive will be required in order to achieve reclamation performance criteria, an adaptive environmental management procedure would be developed by KGCMC and the regulatory agencies, and specified in the GPO. The result would be a veneer of carbonate amended tailings overlying the entire pile. The carbonate material consisting of limestone would be mixed into the tailings either at the mill or during the placement procedure on the tailings pile. The amount of carbonate added would be sufficient to render the tailings non acid-generating. The thickness of the amended tailings veneer would be sized so that all oxygen that diffuses through the cover is consumed within the amended veneer. If a ten foot veneer was amended, it would require 669,000 tons of limestone (95% purity), increasing the tailings footprint to 67.8 acres (Appendix B).

- **Option 3** - same as Alternative #1 except with continuous carbonate addition

This option is the same as Alternative 1, except a continuous carbonate additive would be mixed into the entire volume of new tailings prior to final compaction on the tailings pile. This could be accomplished by adding limestone and thoroughly mixing this material into the tailings. This could take place in the mill or during the placement procedure on the tailings pile. We estimate it would require approximately 2,034,000 tons (1,485,000 cubic yards) of limestone to sufficiently neutralize the tailings (Appendix B). This would result in a 45% increase in the volume of pile, necessitating an expansion in the tailings area to 81.5 acres. An expansion to east or south would further encroach on the Monument, while expansion to the north would be onto high value wetlands and the Cannery Creek drainage.

This option would require a carbonate dry storage area and carbonate/tailings mixing equipment. The physical process of mixing carbonate with the tailings requires hauling carbonate to the mill or tailings site from the barge unloading area. This could require up to 24,000 tons/month of loading on the main “B” Road (as compared to the existing production concentrate haul of 18,000 – 20,000 tons/month and 25,000 ton/month of whole tailings). The carbonate would need to be stored in a dry area, requiring an 18,000 square foot building (approximately 10-day carbonate supply) and access/egress. This could result in a 1-2 acre footprint at the mill or tailings site. There are limited options for expanding either site for this type of facility without excavation into the backslope.

Figure 4 – Alternative #1 and options - Existing Tailings Facility Lease Area, and Present and Projected Footprints of Tailings Placement

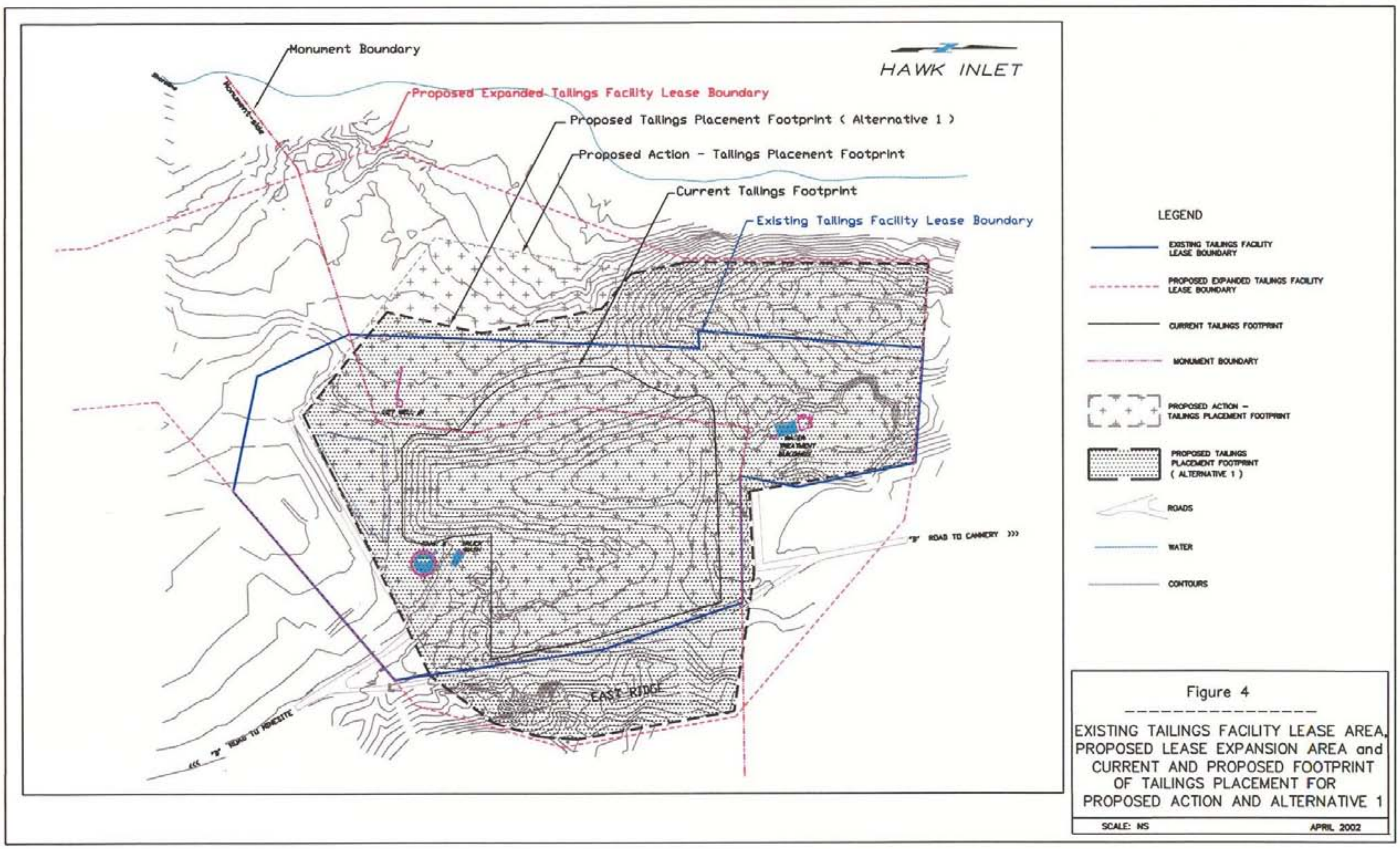
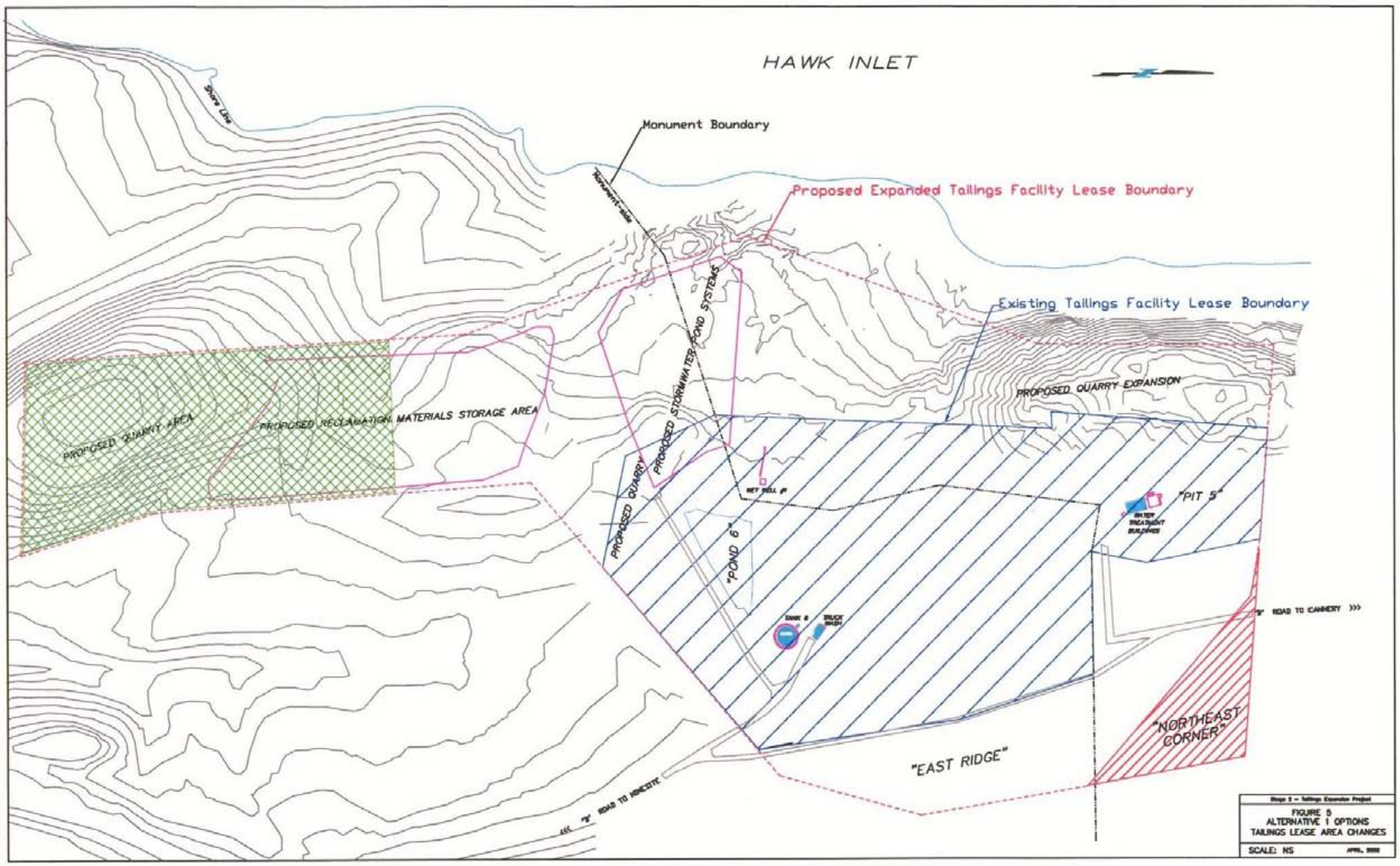


Figure 5 – Alternative 1, Monument Values changes to proposed lease area



PRC Alternatives

Alternative 2 – A pyrite circuit with all pyrite cons stored in containers on pile lease area.

Description of a Pyrite Concentration Plant

The pyrite plant would be located beside the Concentrator at the 920 minesite adjoining the existing facilities. For a nominal rate of 1600 tpd the pyrite plant would include:

- Pyrite Rougher Conditioner Tanks
- Pyrite Rougher Flotation Circuit
- Pyrite Cleaner Flotation Circuit
- Pyrite Final Tails Stock Tank
- Pyrite Thickener
- Pyrite Concentrate Stock Tank

The pyrite circuit is substantial and would have to be located in a highly congested area at the millsite. There would also be a requirement for a sulfuric acid storage area at the millsite, which is not shown in the drawings.

Description of the Pyrite Concentrate Process (see Figure 6)

Pyrite Circuit Feed

Feed to the pyrite circuit would be lead-zinc flotation tail. Lead-zinc flotation tail would be pumped to the pyrite circuit through the existing tailing feed pump box and final tail pumps. Pyrite circuit feed at pH 9 to 11 would flow by gravity to the pyrite rougher conditioner.

Conditioning and Rougher Flotation

Concentrated sulfuric acid would be added to achieve a pH set point of 6 to 9. Conditioner overflow would flow by gravity to the first feedbox of a line of pyrite rougher tank cells. Reagents (SIPX and MIBC) would be added to each rougher cell. Pyrite rougher concentrate would be removed from each cell through launders that would be designed considering the high mass removal required (up to 30-50 tph on the first cell) and high air entrainment in the concentrate. Pyrite rougher tailings would flow by gravity to a pyrite final tails stock tank for neutralization. The pyrite final tails stock tank would have a lime addition point, and pH measurement point. The pyrite final tails stock tank would provide for reaction time for residual acid neutralization prior to thickening. Prior to entering the pyrite final tails stock tank, pyrite rougher tailing from the rougher flotation cells, would be sampled and analyzed by x-ray technology.

Pyrite Cleaner Flotation

Pyrite cleaner flotation would be comprised of flotation cells and SIPX and MIBC would be added to the cleaners. Lime addition after flotation would improve pyrite settling rates and the potential for corrosion in the pyrite thickener. Pyrite cleaner concentrate would flow by gravity to a pyrite thickener feed pump and would be pumped and analyzed for Fe in the 25 to 45% range.

Pyrite Thickening

The pyrite thickener would be 36 feet in diameter and be of a high-rate design with an auto-dilution feedwell. Percol 351 non-ionic flocculent would be added in three stages to the main thickener feedbox. Pyrite thickener overflow would flow by gravity to the pyrite tailings neutralization tank. Pyrite thickener underflow would be sent to storage for filtering. Pyrite thickener underflow would be stored in an approximately 20 foot diameter agitated storage tank.

Pyrite Filtration

The existing Tails 1 filter would be converted to dual duty. Pyrite filter cake production would occasionally exceed immediate filter cake haul truck availability, in the case of mine backfill. The dual feed design allows both pyrite tails and pyrite concentrate to be filtered sequentially to cater to the above conditions.

Reagents

Although consumption of typical reagents (Xanthate (SIPX), MIBC, Milk of Lime, Perol 351) would be similar to existing consumption, there would be a twenty-fold increase in the consumption of sulfuric acid for pH conditioning. This level of consumption would require a substantial increase in the transportation to and on site storage of bulk sulfuric acid.

Description of products

Depyritized tails

The depyritized tails would contain substantially less pyrite than the existing tails it, however, would warrant the same handling due to the residual pyrite and the potential for metals leaching. The EIS baseline work has shown that the potential for metals leaching is of greater concern than the ARD potential at the tailings facility. The potential for metals leaching would not be changed by the removal of a pyrite product. In this alternative and each of its options, the depyritized tails would be stored on the surface pile in the same manner as the whole tails in the proposed action and Alternative #1.

Pyrite Concentrate

The pyrite concentrate would be a highly reactive material, with the potential for spontaneous combustion and the potential to oxidize within a year. The potential methods for dealing with it are onsite storage either above ground, below ground, a combination of the two, or offsite sale or disposal.

Onsite Storage of a Pyrite Concentrate – Above Ground

Onsite possibilities are either on the surface or underground. Disposal methods for pyrite concentrates must deal with the reactive nature of material. It would not be possible to co-store pyrite concentrate and de-pyritized tails together due to the different lag times in the materials reactivity. The lag time of the pyrite concentrate would require rapid encapsulation. The most likely surface disposal scenario would be a series of impoundments to be constructed and closed off annually to oxygen and water. No carbonate additive would be applied. The footprint of the pods would increase the footprint of the surface facility to approximately 86.8 acres.

The pyrite concentrate storage facilities would be located beside the existing tailings impoundment facilities. The material characteristics of a pyrite concentrate vary greatly from the existing tailings material.

For pyrite concentrate storage on the surface, several design criteria must be satisfied to accomplish containment of this highly reactive material:

- The material will have short-term encapsulation requirements. Yearly closures of the pyrite concentrate placement “pods” will be needed to limit oxidation. Total top and bottom encapsulation will be required to limit oxygen ingress and water infiltration.
- Water containment and collection systems will have to be adapted to handle to the potential water quality changes associated with the pyrite concentrates. Potentially separate stormwater facilities will be required. The footprint of the additional stormwater facilities would enlarge the disturbance footprint.
- Foundation and pile structural considerations will reduce overall outside slopes and pile height. Successive placement of pyrite concentrate levels build up on fully contained (lined top and bottom) lifts will limit overall capacity of the piles, even in flat areas. Additional storage space for “wet” pyrite concentrates that result from snow removal and road maintenance operations.

Operational considerations for sequencing the placement of a pyrite concentrate on the surface will include:

- Maintaining several open sets of placement cells to accommodate existing placement criteria, such as weather dependent placement which requires cellular deposition of tailings to allow pore pressures of the materials to relieve prior to placing the next compacted lift.
- Continual modifications of water systems to follow the “pod” development.
- Limiting risk of accidental release for pyrite concentrate road haulage down to tailings as compared to the existing tailings material. Changes requiring additional chemical haulage and storage.

Physical description of Pyrite Surface Storage Concepts

The conceptual pyrite storage facility would ideally be a large flat area. The storage design would entail a bottom to top containment system, possibly made of a plastic style under-liner for the placement of tailings constructed on a foundation. The impoundment would be a system of pods that would limit the extent of time that any pyrite concentrate pile could remain exposed to the environment. The “pods “ would be constructed for the operations group to cycle into a multiple of area’s with active placement cells, along with “pods” that are under construction and also with other “pods” in the process of encapsulation with the placement of a plastic-style liner over the filled “pod”.

The overall setup will resemble sets of areas at various stages of development to accommodate production needs, and given the site setup and storage concepts will require a footprint increase. “Pod” size would be limited to the expected yearly production levels. It is anticipated that the development area needed for such a surface storage area would require twice the footprint as compared to the current placement methods. Consequently, this option would require an expanded tailings footprint of 86.8 acres.

The location of the storage area would focus on the mild slope areas to the southwest of the existing tailings facility to maximize the storage pile capacity. Extension of stormwater systems and water collection systems including road and utility infrastructures would be required to maintain the facilities.

Option 1 – A pyrite circuit with all pyrite cons stored in mine with cement for stability

This option is the same as Alternative 2, except the total volume of pyrite concentrate that is produced by the PRC would be placed back into the mine. KGCMC currently adds 5 percent cement to the whole tailings placed underground. The carbonate contained in this amount of cement is not enough to buffer the potential acidity contained in the pyrite concentrate. Owing to placement of the higher density pyrite concentrate underground, the surface tailings could decrease in size to 61.5 acres (Appendix B).

This option will also require a pyrite concentration storage facility to use in the event that the underground mine is not able to accept the concentrate at the same rate it is produced. Daily adjustments to backfill schedules due to placement openings, equipment availability and mining cycles may result in excess pyrite concentrate being processed on a short-term basis. This concentrate would need to be stored in a covered containment facility that will prevent the onset of ARD, and guard against the potential for material combustion due to the concentrate's high heat of reactivity. The containment facility would be close to the mill site, with appropriate setbacks for fire safety. The size of this facility would be approximately 1 acre.

Option 2 - A pyrite circuit with a portion of pyrite cons stored in mine with cement and carbonate needed for full buffering, remainder stored in containers on pile

This option is the same as Alternative 2, except the pyrite concentrate would be backfilled into the mine as space allows. This amount of pyrite concentrate (3,477,000 tons) would be amended with enough carbonate (3,383,000 tons) to buffer the potential acidity contained in the concentrate. The remainder of the pyrite concentrate (3,136,000 tons) would be placed on the expanded tailings pile within a suitable containment zone (Appendix B). Preliminary estimates indicate the amount of carbonate required to sufficiently buffer the pyrite concentrate would add approximately 161 percent to the volume of the pyrite concentrate. See Appendix A for detailed calculations pertaining to required material volumes and tonnage. This option increases the tailings footprint to 104.8 acres because of the larger area required to build containment cells for the pyrite concentrate.

In addition to the pyrite concentration plant described for Alternative 2, this option would also require a carbonate dry storage area, carbonate/concentrate mixing equipment, and an amended concentrate short-term storage area. The physical process of mixing carbonate with the pyrite concentrate requires hauling carbonate to the mill site from the barge unloading area. This could require up to 24,000 tons/month of loading on the main "B" Road (as compared to the existing production concentrate haul of 18,000 – 20,000 tons/month and 25,000 ton/month of whole tailings). The carbonate would need to be stored in a dry area, requiring an 18,000 square foot building (approximately 10-day carbonate supply) and access/egress. This could result in a 1-2 acre footprint at the mill site. There are limited options for expanding the mill site for this type of facility without excavation into the backslope.

The rate of placement of the amended pyrite concentrate underground depends on the availability of void space available for backfilling. The amount of available space will fluctuate on a regular basis, therefore a contained storage area for the amended pyrite concentrate would be needed to handle situations when the mine cannot accept backfill material at the same rate it is being produced. This storage facility would need to be covered to prevent the amended concentrate from changing its water content, and to prevent the onset of ARD. The aspect of the pyrite concentrate being able to self-ignite will also be a safety concern at the site. The size of the storage facility at the mill site could be several acres, depending on the degree of flexibility the operation has on generating an amended versus non-amended pyrite concentrate, and the variability of available underground storage area.

Option 3 - A pyrite circuit with pyrite cons shipped off-island

This option is the same as Alternative 2, except the pyrite concentrate would be shipped off-island. The material would either be shipped to a hazardous waste landfill, or sold to a buyer that would process the concentrate for the remaining metal value. The buyer would assume the responsibility of disposing of any waste products formed as a result of further processing.

Sale & Offsite Disposal

At this time it does not appear that there are any available buyers for the pyrite concentrate. Offsite disposal by storage overseas is precluded by the Basel protocol, which allows transport overseas only for sale. Disposal to a licensed facility within the US cannot be done at a cost that would allow the mine to stay open. Jim Calvin of the McDowell Group has verified offsite disposal costs and the lack of sale possibilities. His report is Appendix C to this paper.

Option 4 – A pyrite circuit with a portion of tailings processed, pyrite concentrates amended and placed underground (NNP = 0), blend of de-pyritized and whole tailings amended (NNP = 0) and placed in tailings expansion.

This option differs from Alternative 2 in that only a portion of the tailings will be processed in the pyrite reduction circuit. Approximately 7,123,000 tons of whole tailings would be processed (53.4 % of total) creating 3,533,000 tons of concentrate that would be fully amended with limestone (3,438,000 tons) to achieve a NNP of 0. This material would be placed underground. The remaining whole tailings (6,210,000 tons) would be blended in some fashion with the de-pyritized tailings (3,590,000 tons) and would be amended with limestone (1,095,000 tons) and placed at the surface in the tailings expansion. The resultant mixture of whole tailings, de-pyritized tailings, and limestone would also have an NNP of 0. The facility would have to be expanded to 96.5 acres to accommodate the additional volume of limestone in this option.

This option has operational issues similar to Option 2 involving hauling and the storage of carbonate, the ability to mix the carbonate material with the pyrite concentrates, and the need for a suitable storage area for the amended pyrite concentrates. In this option, the area needed for amended pyrite concentrate prior to placement underground depends on the flexibility of the operation to generate pyrite concentrates when room is available underground. An additional facility would also be needed at the mill site to blend the de-pyritized and whole tailings.

Option 5 – portion of tailings processed, pyrite concentrates amended and placed underground (NNP = -339), blend of de-pyritized and whole tailings placed in tailings expansion without amendment.

This option differs from Alternative 2 in that only a portion of the tailings will be processed in the pyrite reduction circuit. Unlike option 4, the pyrite concentrate would not be fully amended with limestone to achieve a NNP of 0. Instead, the target NNP for the backfilled concentrate would be the same level as currently found in the whole tailings that are currently being backfilled in the mine (NNP = -339 tons $CaCO_3$/1,000 tons tailings). Approximately 9,076,000 tons of whole tailings would be processed (68.1 % of total) creating 4,502,000 tons of concentrate that would be amended with 2,584,000 tons of limestone to achieve a NNP of -339. This material would be placed underground. The remaining whole tailings (4,257,000 tons) would be blended in some fashion with the de-pyritized tailings (4,574,000 tons) and would be placed at the surface in the tailings expansion. The resultant mixture of whole tailings and de-pyritized tailings would have an NNP of -16. The facility would have to be expanded to 90.3 acres to accommodate the additional volume of limestone in this option.

This option has operational issues similar to Option 4 involving hauling and the storage of carbonate, the ability to mix the carbonate material with the pyrite concentrates, and the need for a suitable storage area for the amended pyrite concentrates.

Figure 6 – Potential Pyrite Circuit Location

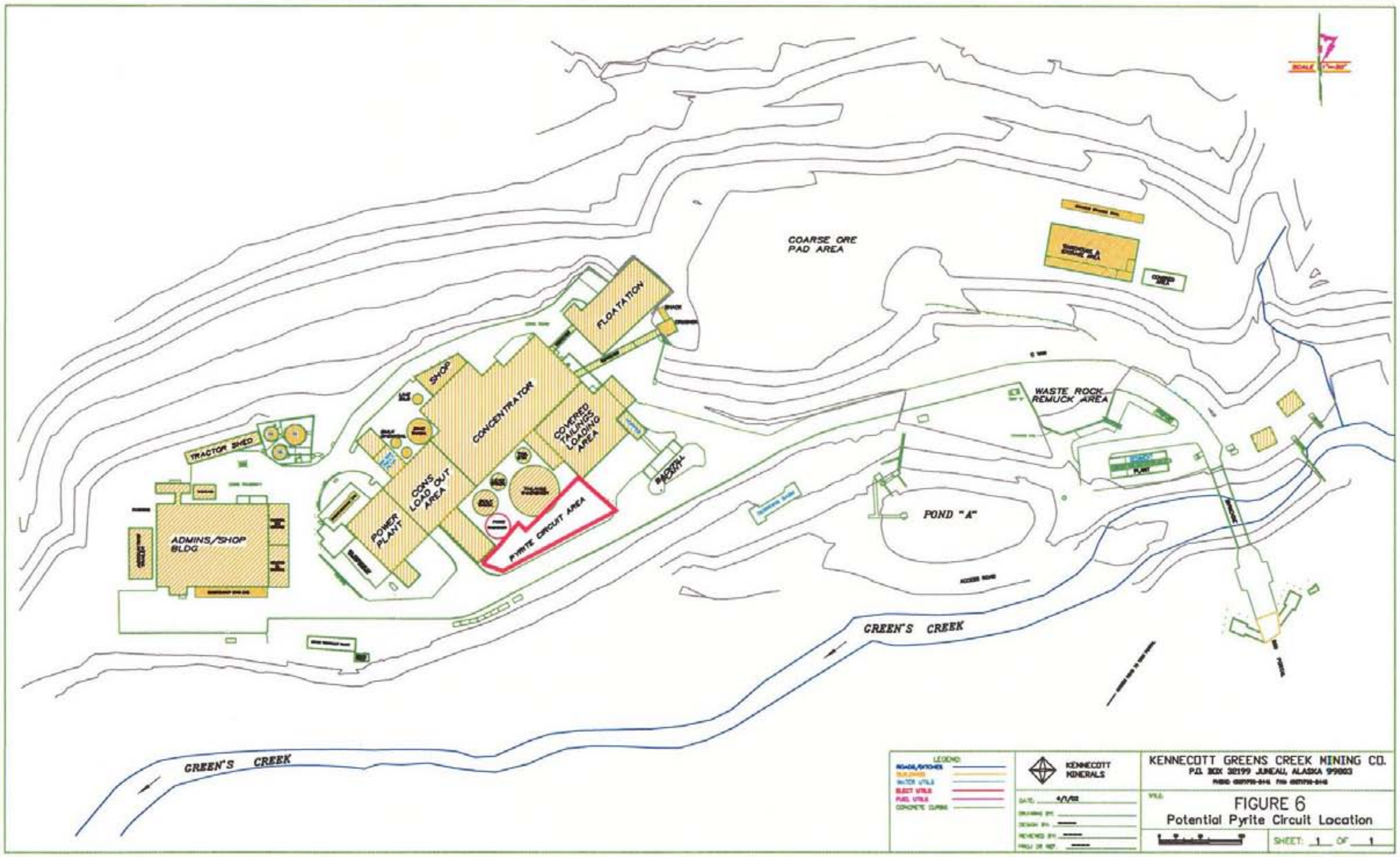


Figure 7 – Potential Pyrite Circuit Building Layout

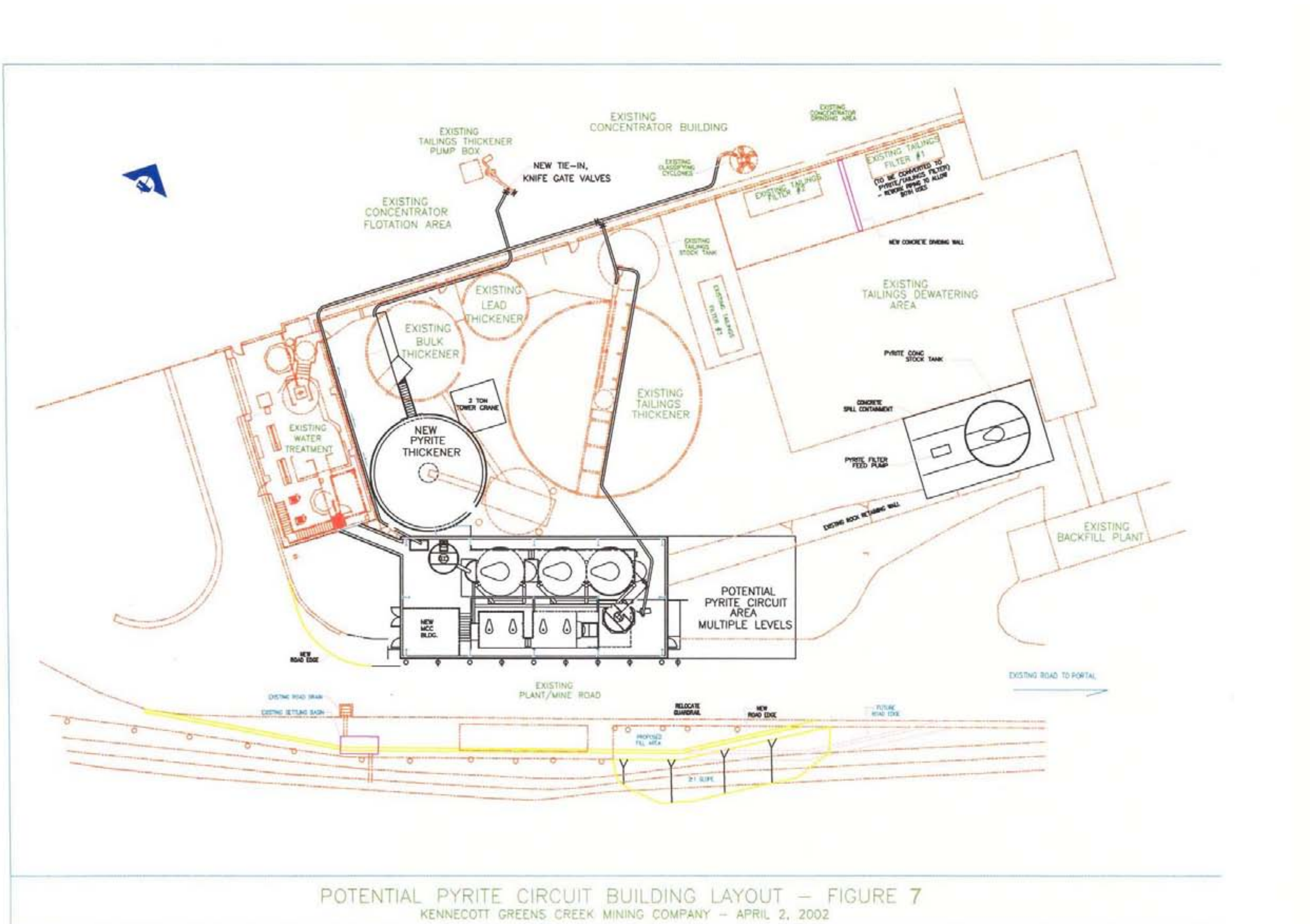


Figure 8 – Floatation Process Flowsheet

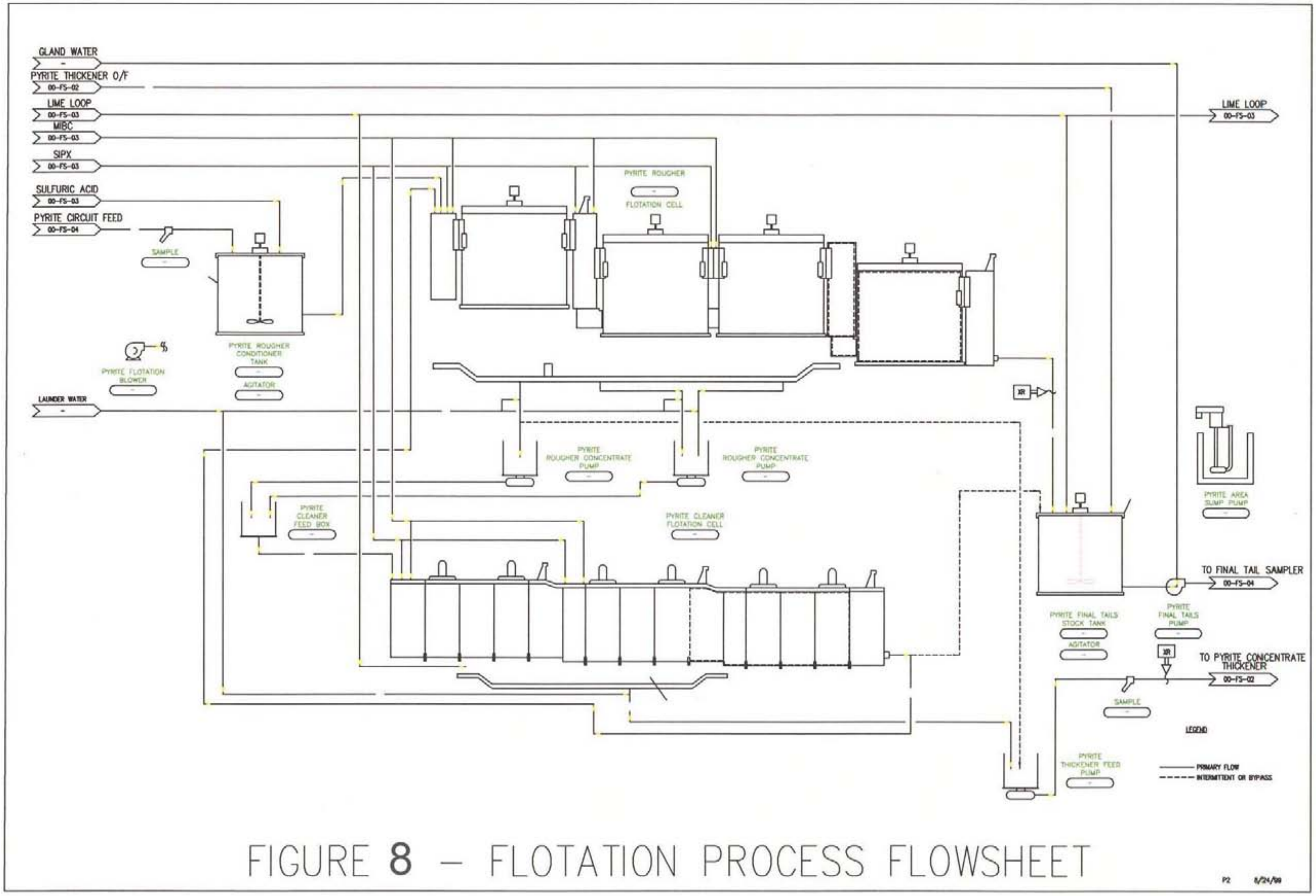


FIGURE 8 – FLOTATION PROCESS FLOWSHEET

Alternatives Comparison Summary

An alternative comparison summary is shown in Table 1. This table presents a comparison of tailings tonnage, amendment quantity, amount and placement of pyrite concentrate, and surface pile footprint area.

Table 1 **Alternative**	**Tailings placed underground (tons)**	**Tailings placed on Surface (tons)**	**Amendment quantity (tons)**	**Pyrite Cons placed underground (tons)**	**Pyrite Cons placed on surface (tons)**	**Tailings facility area (acres)**
No Action	0	0	0	NA	NA	23.2
Proposed action	7,333,000 whole tailings	6,000,000 whole tailings	733,000 tons cement	NA	NA	61.3
Alternative 1 – East Ridge+ the monument values boundary changes + carbon addition as a veneer if needed	7,333,000 whole tailings	6,000,000 whole tailings	59,220 tons carbon plus 733,000 tons cement	NA	NA	62.2
Option 1 – Same as above except with continuous carbon addition	7,333,000 whole tailings	6,000,000 whole tailings	60,000 tons carbon plus 733,000 tons cement	NA	NA	62.2
Option 2 – Same as above except with carbonate addition as a veneer if needed	7,333,000 whole tailings	6,000,000 whole tailings	669,000 tons limestone plus 733,000 tons cement	NA	NA	67.8
Option 3 – Same as above except with continuous carbonate addition	7,333,000 whole tailings	6,000,000 whole tailings	2,034,000 tons limestone plus 733,000 tons cement	NA	NA	81.5
Alternative 2 - A pyrite circuit with all pyrite cons stored in containers on pile lease area.	6,077,000 de-pyritized tailings	642,000 de-pyritized tailings	608,000 cement	0	6,613,000	86.8
Option 1 – Same as above except pyrite cons stored in mine w/ cement for stability	1,727,000 de-pyritized tailings	4,993,000 de-pyritized tailings	834,000 tons cement	6,613,000	0	61.5
Option 2 – Same as above except a portion of pyrite cons stored in mine w/ cement and carbonate needed for full buffering, remainder stored in containers on pile.	0	6,720,000 de-pyritized tailings	3,383,000 carbonate and 686,000 tons cement	3,477,000	3,136,000	104.8

Option 3 – Same as above except pyrite cons shipped off island.	No Options available					
Option 4 – enough whole tailings processed to fill u/g capacity with carbonate added to raise NNP to 0, de-pyritized tailings blended with whole tailings amended to raise NNP to 0 and placed on surface	0	3,590,000 tons de-pyritized tailings and 6,210,000 tons whole tailings	3,438,000 tons limestone u/g , 1,095,000 tons limestone surface, 697,000 tons cement	3,533,000 tons pyrite concentrates	0	96.5
Option 5 – enough whole tailings processed to fill u/g capacity with carbonate added to raise NNP to same as whole tails currently placed u/g (NNP = -339), de-pyritized tailings blended with whole tailings unamended and placed on surface	0	4,574,000 tons de-pyritized tailings and 4,257,000 tons whole tailings	2,584,000 tons limestone u/g, plus 736,000 tons cement	4,502,000 tons pyrite concentrates	0	90.3

1 – assume a veneer thickness of 10 feet and 3% organic carbon addition by weight.
2- assume addition at a ratio of 1% organic carbon by weight.
3- assume a rate of carbonate addition of 33.9% by weight to a veneer 10 feet thick
4- assume a rate of carbonate addition of 33.9% by weight to all tailings
5- assume that carbonate is added at a rate of 97.3% of the tonnage of concentrate (less the buffering capacity of the added cement

6 – See the appendix for calculations

3.0 Screening Evaluation Comparison Factors and Ratings

This section describes how the scoping issues discussed in Section 1.0 were would be addressed in each of the alternatives. The factors to compare the alternatives developed in Section 2.0 (Alternatives Development) are listed below.

3.1 Evaluation Criteria

Fundamental to the options screening process is evaluation of each criterion to identify an objective range of impacts caused by one or more alternatives. These impacts reflect the concerns of the public and the agencies. The ratings identified for each criterion varied. Some reflected a specific regulatory standard or limit, such as Alaska Water Quality Standards (AWQS) that provide a measurable endpoint. Exceeding those standards might represent an unacceptable impact on the resource and therefore could result in screening out that alternative. Other criteria were not as well defined, such as Monument Values and therefore were more subjective. These were ranked by using best professional judgment.

ARD Risk

Acid rock drainage (ARD) can be defined as a leachate having characteristic water chemistry resulting from geochemical conditions occurring within pyrite bearing materials, such as the tailings or pyrite concentrate. Typical ARD chemistry includes high levels of acidity, dissolved solids (including sulfate), low pH, and usually includes highly elevated metal concentrations. ARD potential can be measured by static and kinetic tests that determine the net neutralization potential of the material. Due to the complex geochemical processes involved in ARD formation, ARD may begin forming immediately, or may take hundreds to thousands of years to develop. In certain situations, ARD may never develop.

For the purposes of this evaluation, the time period of ARD risk is considered to be hundreds of years. Beyond this time frame, global geological processes (e.g., gross erosion, mass wasting) are bound to occur in this area, and the magnitude of these global processes will likely change the geochemical and structural character of any tailings material storage area. The likely occurrence of these processes overrides the predictability of ARD formation beyond this time period. ARD risk hazards are rated below:

- No or low risk – No or very low risk that geochemical conditions would develop in the tailings material or concentrate such that leachate chemistry would be characteristic of ARD.
- Moderate risk – A medium risk that geochemical conditions would develop in the tailings material or concentrate such that leachate chemistry would be characteristic of ARD.
- High risk – Significant risk of geochemical conditions developing in the tailings material or concentrate such that leachate chemistry would be characteristic of ARD.

Metals Leaching Risk

Metals leaching results from geochemical conditions within the tailings, pyrite concentrate or natural mineralized formations that form a leachate containing elevated metal levels and neutral pH. Metals leaching is not necessarily associated with ARD, and can develop in conditions having high carbonate buffering capacity. It can occur as a result of the oxidation of metal-bearing minerals that creates more soluble oxidized forms of key metals such as zinc. The metals are released into solution as the tailings are rinsed by infiltrating surface water or groundwater. Metal leaching can also occur naturally around the site from any mineralized zone. As in the evaluation of ARD risk, the time period of metals leaching risk is considered to be hundreds of years. Metal leaching risks are rated below:

- No or low risk – No or very low risk that geochemical conditions would develop in the tailings material or concentrate such that leachate chemistry would contain elevated metals as a result of metals leaching processes.
- Moderate risk – A medium risk that geochemical conditions would develop in the tailings material or concentrate such that leachate chemistry would contain elevated metals as a result of metals leaching processes.
- High risk - Significant risk that geochemical conditions would develop in the tailings material or concentrate such that leachate chemistry would contain elevated metals as a result of metals leaching processes.

Risk of Exceeding AWQS

All waters that come into contact with mine waste materials are required to meet AWQS. This includes water emanating from the production rock storage areas, tailings pile and underground mine during operations, closure and a post closure period. Most water is currently captured, treated and discharged under the mine's existing NPDES permit. KGCMC has proposed modifying the discharge permit to allow for a higher flow rate due to the increased footprint of the expanded tailings pile.

Potential causes of exceeding the AWQS include ARD and metals leaching. Potential mitigation measures include additional capture facilities, use of amendments, development of a PRC, mixing waters to achieve a dilution affect prior to release to the environment, mixing discharged waters with receiving waters within a designated mixing zone (with or without treatment), biological treatment (low energy requirement), and mechanical treatment using KGCMC's water treatment plant.

Alaska water quality standards were developed to protect all existing uses and the level of water quality necessary to protect existing uses of surface and groundwater that may occur anywhere in the state. As a consequence, standards are set at very low levels to protect uses, some of which may have stringent water quality requirements. For example, Alaska groundwater standards for metals are based on supporting propagation of fish, shellfish, other aquatic life and wildlife . The Alaska standards contemplate potential groundwater withdrawal for hatcheries or aquaculture. In evaluating the risk of exceeding AWQS, the project team differentiated between risks of exceeding water quality permit requirements (such as exceeding groundwater monitoring detection monitoring triggers under the solid waste permit), from risks of harming an existing use (e.g. making a water unsuitable for use as drinking water). The assessment of risk was based on potential harm to existing and reasonably foreseeable uses of water downgradient of the facility (e.g. drinking water use of groundwater, and protection of fish, shellfish, other aquatic life and wildlife in surface water or marine environments). Consequently, short-term exceedences of water quality standards for metals in groundwater adjacent to the facility (which may occur at some point in the future due to imperfections in the containment system), would not necessarily cause a ranking of moderate or high risk to AWQS, so long as existing uses were protected. AQWS exceedance risks are rated below:

- No or low risk – No or low risk of authorized NPDES discharges or any uncaptured groundwater or surface water discharges impairing an existing use.
- Moderate risk – Moderate risk of impairing an existing use.
- High risk – Significant risk of impairing an existing use.

Monument Values

For the purposes of this evaluation of tailings disposal options, monument values include the overall size of the tailings pile, the magnitude of maintenance required for the tailings pile and/or underground mine water, and the overall impact of tailings and/or pyrite concentrate management on the Monument's natural resources. Visual impacts are considered separately below. A Monument Values boundary change based on reducing the disturbed area within the Monument is described as part of Alternative #1. Monument value risks area rated below:

- No or low impact – No or low impact to monument values expected from the option considered.
- Moderate impact – A moderate impact to monument values is expected from the option considered.
- High impact - Significant impacts to monument values are expected from the option considered.

Reclamation

Reclamation addresses the return of exploration areas and mine facilities to a stabilized condition to ensure long-term protection of land and water resources in a manner compatible with the selected post-project land use. An existing reclamation plan is included as part of the GPO, and provides guidance and performance standards to be met to achieve successful reclamation. The ratings identified are based on the likelihood of successful reclamation as described in the GPO.

- No or low potential – Lower likelihood of unsuccessful reclamation with a corresponding decreased potential for minimizing impacts to water quality and/or a increased potential to achieve a post-mining land use consistent with the GPO.

- Moderate potential – moderate potential of successful reclamation with a corresponding moderate potential for impacts to water quality and/or moderate potential to achieve a post-mining land use consistent with the GPO.

- High potential – Higher likelihood of unsuccessful reclamation with a corresponding increased potential for unacceptable impacts to water quality and/or a decreased potential to achieve a post-mining land use consistent with the GPO.

Visual

Visual impacts are those associated with a change in the visual landscape of the tailings pile as seen from Hawk Inlet or the air. They are directly related to the size or appearance of a facility, and in the case of the tailings pile somewhat related to reclamation due to the type of vegetated cover prescribed in the GPO. The ratings are relative to the visual impact anticipated from the existing tailings pile if it were completed to the proposed size and reclamation standard.

- No or low impact – No or low visual impact as compared to the visual impact anticipated from the existing tailings pile if it were completed to the permitted size and reclamation standard.
- Moderate impact – a moderate visual impact as compared to the visual impact anticipated from the existing tailings pile if it were completed to the permitted size and reclamation standard.
- High impact - a significant visual impact as compared to the visual impact anticipated from the existing tailings pile if it were completed to the permitted size and reclamation standard.

Technical Feasibility

The technical feasibility of project options must be addressed. If components become too complex or use uncertain technology, an increased risk of failure could result. Some items of specific concern are: adequate tailings/pyrite concentrate storage capacity and material stability, the water collection, transport, and discharge system, tailings pile stability, and adequacy and access for project materials and supplies.

Certain characteristics of an option may have technical constraints that affect the ability to implement that option. For example, topography, hydrology, geochemistry, resource limitations (e.g., carbonate or carbon additive sources), or engineering knowledge for a specific option may influence the acceptability of that particular option for meeting its objectives. Issues of importance to this criterion consider the ability of a specific option to meet these challenges.

The ratings identified are based on the technical feasibility and the potential risk associated with not meeting each option's technical requirements.

- No or low impact - No specific technical challenges related to meeting technical requirements.
- Moderate impact - Technically feasible, but the requirements represent a significant challenge. Engineering and operational requirements have not been fully tested, or required resources are unknown. The option evaluated may also face risks to completion as a result of unknown estimates of technical or regulatory acceptance until additional information is collected. Risk of delay or not meeting objectives is moderate.
- High impact - Significant unknowns with respect to engineering feasibility or required resources. High risk associated with not being able to comply with technical or regulatory requirements.

Economic Feasibility

If project costs exceed reasonable or practical limits, economic feasibility could become an issue. If meeting other criteria included in this evaluation means that the project would not meet reasonable financial expectations, then that option may not be feasible for economic or financial reasons. The Forest Service will make that decision. The ratings identified are based on the engineering and ancillary costs of project development and operations and the environmental mitigation and other costs that may be required to develop an acceptable and approved project. In Table 2, ratings for Economic Feasibility are blended with the ratings for technical feasibility. Relative economic impact is rated below

- No or low impact - No substantive additional cost required to meet technical or regulatory requirements.
- Moderate impact - Significant costs required to meet technical or regulatory requirements.
- High impact - Extraordinary costs required to meet technical or regulatory requirements.

4.0 Alternatives Screening Process

This section describes the process by which the alternatives/options identified in Section 2.0 (Alternatives Development) were screened with the comparison factors described in Section 3.0 (Screening Evaluation Criteria and Ratings) based on the issues identified during scoping. The purpose of screening was to compare alternatives in term of meeting acceptable environmental, technical, or economic standards. It provides a method to determine which options are best suited to be retained for detailed analysis in the EIS.

4.1 Alternatives Screening

This section describes the methods and results of applying the comparison factors ratings to screen each alternative/option. Screening was done by an interdisciplinary group consisting of technical resource specialists from the third-party EIS team. Rating values (low, moderate, and high) were assigned to each issue factor, and each alternative/option was either recommended to be dropped from further consideration or retained for detailed analyses in Chapter 4 (Environmental Consequences) of the EIS.

Screening was done in a two-step process. First, a fatal flaw analysis was completed. In the second step, values were assigned based on the impact of each alternative and option for each issue criterion.

For the fatal flaw analysis, a fatal flaw was defined as a condition in which an alternative or option could not meet a specific, measurable performance threshold required to meet a particular project objective. An example would be being able to meet a specific discharge standard for an NPDES permit.

In the second step, each alternative/option was compared to the ratings for each of the evaluation criteria. This resulted in the assignment of an impact value. In some comparisons, measurements were largely qualitative, whereas in other cases it was possible to quantify potential impacts.

Because NEPA regulations require that an applicant’s proposed project be evaluated as a separate alternative in the EIS, the alternative that constitute KGCMC’s original proposed action is automatically recommended for detailed analyses as a separate project alternative (Proposed Action).

For each alternative and option, the following sections discuss the evaluations and decisions made based on potential impacts associated with each of the issue criteria. The discussions focus on options that received moderate or high values for a particular impact or that were otherwise important in determining whether an option was dropped from further consideration or retained for detailed analyses. Thus, if a particular evaluation rating did not differentiate impacts between alternatives or options, or if a low value was assigned, it was not discussed.

4.2 Alternatives Screening Results

4.2.1 Fatal Flaw Analysis

As previously mentioned, a fatal flaw was defined as a condition in which an alternative or option could not meet a specific, measurable performance threshold required to meet a particular project objective. Of all alternatives and options evaluated, Alternative 2, Option 3 –a pyrite circuit with all pyrite cons shipped off island- did not pass the fatal flaw analysis.

Jim Calvin, managing partner and minerals economist for the McDowell Group conducted a separate review of the potential for off site disposal of pyrite concentrate. His findings indicate that disposal to a licensed facility within the US cannot be done at a cost that would allow the mine to stay open. His report is included as Appendix C to this paper.

4.2.2 Alternative Rating Comparisons

ARD Risk

Most alternatives had a low ARD risk because of the high carbonate content of the tailings, which delays the onset of acidic conditions; and the diminished oxygen availability after reclamation, which reduces long-term ARD risk. Placement of un-amended pyrite concentrate underground has a high ARD risk because the concentrate would likely become acidic before flooding or closure of the mine. The ARD risk of pyrite concentrates placed underground can be partially mitigated by adding limestone. While addition of limestone to achieve a NNP value of 0 should theoretically create a mixture that will not become acidic, the geochemical behavior of amended tailings are not known with certainty. Materials with an aggregate NNP of 0 may have the risk of becoming acidic, especially when the material contains an abundance of pyrite. Additionally, the degree of mixing between the concentrate and the limestone is not known. Poor mixing may increase the ARD risk. Consequently, amended concentrates have a moderate ARD risk. Placement of the pyrite concentrate in a containment facility near the tailings facility had a moderate ARD risk because acidity is more likely to form during operations than with a whole tailings process.

Metals Leaching Risk

The addition of carbon to tailings has the ability to decrease metal leaching risk relative to other alternatives/options. The alternatives not having carbon addition have a moderate risk for metals leaching. Metal leaching occurs currently but contact water is collected and treated so that water quality is protected. If tailings acidify in the long-term, then a high risk of metals leaching would develop. Placement of pyrite concentrate without limestone additive as mine backfill would have a high risk for metal leaching. As discussed above under ARD risk, concentrates amended with limestone have a moderate ARD risk owing to the uncertainty of the geochemical behavior of the material and to the unknown degree of mixing that will be achieved. For these reasons, the metals leaching risk of limestone amended concentrates is moderate.

Risk of Exceeding AWQS

A water collection, treatment, and marine discharge system has been developed at Greens Creek to deal with elevated metal concentrations in contact water. The system has proven to be reliable, and will be able to satisfy the increases in treatment capacity required for each alternative/option. Additionally, since the quantity of contact water will greatly decrease after closure, the existing treatment system, or an alternative water management program will be able to protect water quality after closure. This assessment of risk is predicated on application of a suitable adaptive environmental management plan. Such a plan relies on development and application of a rigorous program of inspection, geotechnical, geochemical, and water quality monitoring, calibration, and verification of predictive models and periodic formulation of model predictions, and on-going review and modification of management techniques by a panel of stakeholders. Application of such a plan would, for example, identify and mitigate any failure of a containment or treatment system or discharge option that impaired water quality. As a consequence, all but one option has a low risk for exceeding Alaska water quality standards. The placement of a pyrite concentrate in the mine with cement for stability would have a high risk of violating AWQS in groundwater downgradient of the underground mine after closure.

Monument Values

The PRC options for placing pyrite concentrate underground received high impact ratings due to the potential groundwater impacts near the mine once the de-watering pumps are removed and the groundwater returns to its pre-mining levels. If mine drainage occurs after closure and the water does not meet AWQS, the drainage would have to be collected from seeps and/or the portal. If the water needs to be treated prior to discharge, a pipeline would be required to route the water to the treatment facility. If this facility is located near the pile, then the existing pipeline route that conveys water from the mine area to the existing treatment plant could be used. Another option is to locate the treatment facility near the mine. In either case, this would require that the route to the mine remain open for operator access. Additionally, the potential for an underground fire associated with spontaneous combustion of the pyrite is possible due to the high heat of reaction of the pyrite concentrates. The continuous carbonate addition option was rated high due to the tailings pile expansion into the monument that would be required in order to contain the additional volume (45 %) of material. The PRC option that places all of the pyrite concentrate on the surface and the remaining whole tailings options were considered to have a moderate impact, less than those previously discussed.

Reclamation

Placing the pyrite concentrate in a containment facility within the tailings pile footprint would cause a high potential for unsuccessful reclamation, due to the uncertainties involved with the type of facility that would be appropriate, its location, and the ability to create a suitable reclamation cover. The continuous carbonate addition option and the PRC options that place pyrite concentrates on the surface were also rated high due to the large increase in tailings volume that would be required. The other options all received a moderate rating, as it was determined they would have a lesser risk of unsuccessful reclamation than those options previously discussed.

Visual

The continuous carbonate addition option and the PRC options that place pyrite concentrates on the surface was rated high due to the large increase in tailings volume that would be required. This would result in a much more visible tailings pile than the other alternatives/options. All other alternatives/options received a moderate rating, as it was determined they would have a lesser visual impact than the continuous carbonate addition option.

Technical Feasibility

Pyrite concentrate would need to be quickly placed and isolated from oxygen to avoid rapid oxidation, acidification, metals release, and heating due to pyrite's heat of reaction. Design and construction of a secure long term repository for the concentrate would be challenging.

Carbonate addition presents technical challenges associated with placement and mixing that cause a moderate risk of impact. If carbonate is not adequately mixed, acidification may still occur. Additionally, mixing and adding limestone to tailings may compromise the tailings density achieved during placement, leading to stability concerns. Addition of carbonate throughout the period of tailings placement would increase overall tailings volume by 45 % necessitating an expansion in the facility footprint. Calculation of the appropriate veneer thickness of a carbonate amended tailings is subject to errors because of the difficulty in predicting the depth of oxygen penetration after placement of the oxygen-excluding cover.

Carbon addition also presents technical challenges that would impart a moderate risk of environmental impact. If carbon is added in a liquid form it would only persist until the first pore volume of water rinsed through the pile (e.g. tens of years). Uniform replenishment of liquid carbon presents additional technical challenges. If carbon is added in a solid form (e.g. biosolids, bark), it would persist for longer (but not indefinitely) in the pile but a larger quantity would be required. The solid carbon sources may reduce the strength of the tailings, which may reduce the stability of the tailings or of the overlying cover.

Economic Feasibility

The PRC options were rated high due to the large capital and operating costs associated with installation of a PRC. Marshall (2002) indicates that this process could involve capital costs of $26 per ton of pyrite concentrate and capital costs of $53M US. The continuous carbonate addition option was also rated high due to the large operating cost associated with importing approximately 2,034,000 cubic yards of limestone to the site. The carbonate veneer option and the two carbon options all had a moderate rating. This is due to lesser amounts of limestone required, and the lower costs of obtaining and placing a carbon additive.

4.3 Alternatives Screening Summary

A summary of the alternatives screening is described below and shown in Table 2. Section 4.3.1 sets forth those options we recommend be dropped from further consideration. Section 4.3.2 discussed those options we believe should receive a detailed analysis in the EIS. A more detailed description of the criteria ratings is found above in Section 4.2.2.

4.3.1 Alternatives Recommended To Be Dropped From Further Consideration

- Alternative 1, Option 2 - carbonate addition as a veneer if needed. We recommend against further consideration of this option because it had a moderate rating for metals leaching risk, which is a higher risk than the carbon amendment options as described below. Consequently, when the two chemical means of mitigating ARD and metals leaching risk are compared, the carbon addition option is superior because it addresses both ARD and metals leaching concerns. Addition of carbonate only addresses ARD risks. It will also require a larger area (9% increase) for the tailings pile than the carbon amendment option. If this option is retained for detailed evaluation, no additional baseline work is required.
- Alternative 1, Option 3 - continuous carbonate addition. We recommend against further consideration of this option for the reasons stated above plus the larger area requirement (31% increase). If this option is retained for detailed evaluation, no additional baseline work is required.
- Alternative 2 - A pyrite circuit with all pyrite cons stored in containers on pile lease area. We recommend against further consideration of this option due to the high risk to reclamation (type of containment, size and suitable reclamation cover), technical feasibility (integrity of long term repository), and economic feasibility. If this option is retained for detailed evaluation, a conceptual design for the containment facility would be required in order to complete the baseline study.
- Alternative 2, Option 1 - pyrite cons stored in mine with cement for stability. We recommend this option not be retained for further consideration due to the high risks for ARD, metals leaching, violation of AWQS, damage to monument values, and expense. If this option is retained for detailed evaluation, a baseline study that predicts the post closure hydrology of the mine workings will be required.
- Alternative 2, Option 2 - a portion of pyrite cons stored in mine with cement and carbonate needed for full buffering, remainder stored in containers on pile. We recommend against further

consideration of this option due to the high potential for mine drainage containing ARD and metals, reclamation difficulties, the technical difficulty of developing suitable containment facilities and a suitable method of blending the cons and the carbonate material, and the high costs. If this option is retained for detailed evaluation, a baseline study that predicts the post closure hydrology of the mine workings will be required. Additionally, if this option is retained for detailed evaluation, a conceptual design for the containment facility would be required in order to complete the baseline study.

- Alternative 2, Option 3 –pyrite concentrate shipped off-island. Because there is no available site to ship the pyrite concentrate to, this option has a fatal flaw, and is not further evaluated in the options screening process.
- Alternative 2, Option 4 – a portion of whole tailings processed, all pyrite cons stored in mine with cement and carbonate needed for full buffering, blend remaining whole tailings and de-pyritized tailings, fully amended and store in pile. We recommend against further consideration of this option due to the high potential for mine drainage containing ARD and metals, the increased visual impact, reclamation difficulties, the technical difficulty of developing a suitable method of blending the cons and the carbonate material, and the high costs. If this option is retained for detailed evaluation, a baseline study that predicts the post closure hydrology of the mine workings will be required. This study would include post closure flows, water quality and seep locations, and means of managing the flows such that AWQS are met. In addition, the beneficial environmental effects, if any, of placing a blend of amended, de-pyritized tailings and whole tailings instead of whole tailings in the tailings facility also need to be further evaluated. Also, the feasibility of mixing the three materials (de-pyritized tailings, whole tailings, and limestone), and the logistics of handling the three materials would also have to be evaluated.
- Alternative 2, Option 5 – a portion of whole tailings processed, all pyrite cons stored in mine with cement and carbonate needed to bring NNP to same value as found currently in whole tailings being backfilled (NNP = -339), blend remaining whole tailings and de-pyritized tailings and store in pile. We recommend against further consideration of this option due to the high risks to monument values due to potential mine drainage containing ARD and metals and the large increase to the size of the pile, the high risk for reclamation due the difficulties in creating suitable containment facilities for the cons on the pile, the high risk of visual impacts due to the large increase in the size of the pile, the high risk of technical feasibility due to developing a suitable method of adequately blending the cons with the carbonate material, and the high risk for economic feasibility due to the costs associated with developing a pyrite circuit and carbonate addition. If this option is retained for detailed evaluation, a baseline study that predicts the post closure hydrology of the mine workings will be required. This study would include post closure flows, water quality and seep locations, and means of managing the flows such that AWQS are met. In addition, the beneficial environmental effects, if any, of placing a blend of de-pyritized tailings and whole tailings instead of whole tailings in the tailings facility also need to be further evaluated. Also, the feasibility of mixing the de-pyritized tailings and whole tailings and the logistics of handling the three materials would also have to be evaluated.

4.3.2 Alternatives Recommended for Detailed Analysis

- Proposed action. This is the EIS proposed action and is therefore recommended for detailed analysis in the EIS.
- Alternative 1 – Same as proposed action except:

- Tailings pile backed away from slope on southwest side of pile, tailings storage on “East Ridge” area of lease.
- Southern boundary of the lease area moved north reducing both the lease area and the disturbed area within the Monument by approximately 22 acres
- Lease area and disturbed area outside the Monument increased by 4.8 acres in northeast corner.
- Carbon addition to the pile as a veneer if needed.

This option is recommended for detailed analysis due to the relatively low risk ratings, the benefit to monument values, and the fact that this option is the same as the Proposed Action in regards to the type of tailings. Overall, this alternative and Option 1 received the lowest ratings for risk of all alternatives/options.

- Alternative 1 Option 1 – same as Alternative #1 except with continuous carbon addition. This option is recommended for detailed analysis in the EIS due to its relatively low risk ratings.
- No Action – as required by NEPA

TABLE 2

KENNECOTT GREENS CREEK MINE
ALTERNATIVE SCREENING MATRIX

Alternative/Option	**ARD Risk**	**Metals Leaching Risk**	**Risk of Exceeding AWQS**	**Monument Values**	**Reclamation**	**Visual**	**Technical Feasibility**
Proposed Action	**L**	**M**	**L**	**M**	**M**	**M**	**M**
Alternative 1- Greens Creeks current proposal + the monument values boundary changes + carbon addition as a veneer if needed	**L**	**L**	**L**	**M**	**M**	**M**	**M**
Option 1 – Same as above except with continuous carbon addition	**L**	**L**	**L**	**M**	**M**	**M**	**M**
Option 2 – Same as above except with carbonate addition as a veneer if needed	L	M	L	M	M	M	M
Option 3 – Same as above except with continuous carbonate addition	L	M	L	H	H	H	H
Alternative 2- A pyrite circuit with all pyrite cons stored in containers on pile lease area	M	M	L	M	H	M	H
Option 1 – Same as above except pyrite cons stored in mine w/ cement for stability	H	H	H	H	L	L	H
Option 2 – Same as above except a portion of pyrite cons stored in mine w/ cement and carbonate needed for full buffering, remainder stored in containers on pile	M	M	L	H	H	M	H
Option 3 – Same as above except pyrite cons shipped off island	*Eliminated due fatal flaw analysis*						
Option 4 – Portion of tailings processed, cons u/g fully amended, and blended de-pyritized and whole tailings on pile with full amendment	M	M	L	H	H	H	H
Option 5 – Portion of tailings processed, cons u/g amended to NNP -339, and blended de-pyritized and whole tailings on pile	M	M	L	H	H	H	H

Note: Economic Feasibility has been merged into the Technical Feasibility column.

L = no or low risk or impact M = moderate risk or impact

H = high or significant risk or impact

APPENDIX A

Table 1. Calculation of required volume of limestone needed to neutralize the pyrite concentrate.

Calculation of Limestone Required to Neutralize Pyrite Concentrate

6,720,000 tons of pyrite concentrate (Appendix B) will be produced from a pyrite reduction circuit. The concentrate has an approximate specific gravity of 4.5 g/cm3, porosity of 40%, and has a dry bulk density of 169 lbs/cubic foot (4.5 g/cm^3 x (1-.4) x 62.4 lbs/cu.ft. / 1 g/cm^3). Consequently, the pyrite concentrate has a volume of (6,720,000 tons x 2,000 lbs/ton / 169 lbs/cu.ft. / 27 cu ft/ cu.yd. = 2,945,431 cu.yd.

Additionally, the concentrate has an acid generating capacity of 966 t/1,000 tons as $CaCO_3$, and a neutralizing capacity of 42 t/1,000 tons as $CaCO_3$ for a net neutralization capacity of 966-42 = 924 t/1,000 tons as $CaCO_3$. Calcite has a specific gravity of 2.72 g/cm3 and with a 40% porosity has a dry bulk density of 101.8 lbs/cu.ft (2.72 g/cm^3 x (1-.4) x 62.4 lbs/cu.ft. / 1 g/cm^3). . The limestone required to neutralize the acidity in the concentrate (assuming 95 % purity) is 924 t/ktons x 6,720 ktons / 95% = 6,536,084 tons. The volume of the limestone is 6,536,084 tons x 2,000 lbs/ton / 101.8 lbs/cu.ft. / 27 cu.ft./cu.yd. = 4,755,937 cu. yd. The volume of limestone added is 161% of the volume of concentrate bringing the total volume of concentrate to 7,701,368 cu.yd. and the tonnage to 13,256,084 tons.

* The tonnage of concentrate and its acid generating capacity was taken from Marshall 2002. The specific gravity of the concentrate and limestone was taken from standard references on the properties of minerals. The specific gravity of concentrate was determined by assuming a majority of the concentrate was pyrite and remainder was quartz. Limestone was assumed to consist of calcite. A porosity of 40% was assumed to calculate the bulk density, a normal value for crushed granular materials.

Table 2. Calculation of the limestone required to neutralize potential acidity in whole tailings.

Calculation of Limestone Required to Neutralize Whole Tailings
6,000,000 tons of whole tailings will be placed in the tailings facility if conventional processing is used (Appendix B). The tailings have an average acid generating capacity of 532 t/1,000 tons as CaCO3, and a neutralizing capacity of 210 t/1,000 tons as CaCO3 for a net neutralization capacity of 532-210 = 322 t/1,000 tons as CaCO3. The limestone required to neutralize the acidity in the whole tailings (assuming 95 % purity) is 322 t/ktons CaCO3 x 6,000 ktons / 95% = 2,033,684 tons.
The limestone required to neutralize all pyrite concentrate was 6,536,084 tons (Table 1) which is 321% of the 2,033,684 tons needed to neutralize the whole tailings.
The limestone added to whole tailings has a volume of 2,033,684 tons x 2,000 lbs/ton / 101.8 lbs/cu.ft. / 27 cu.ft./cu.yd. = 1,479,796 cu. yd. The limestone addition will increase the volume of whole tailings from 3,314,919 cu.yd to 4,794,715cu.yd., a 44.6% increase in volume.*

*The tonnage of whole tailings and its acid generating capacity was taken from Marshall 2002. The value provided for the acid generating capacity was similar to values measured by SMI (1999). The specific gravity of the tailings was from Kennecott baseline reports while the specific gravity of limestone was taken from standard references on the properties of minerals. Limestone was assumed to consist of calcite. A porosity of 40% was assumed to calculate the bulk density, a normal value for crushed granular materials.

Appendix B

Calculations Support for scale up to Stage 2 design capacity

From Keith Marshall's Memo dated Feb 19, 2002

The numbers in the memo reflect current mine reserves and must be scaled up to reflect the potential storage capacity of the Stage 2 expansion.
The Stage 2 tailings facility was designed to hold a minimum of 6 million tons of tailings materials over the current existing pile. This design reflects potential development of additional reserves past the current mine plan estimate of the next 12 years. Scale up utilizes the same distribution of backfill tons and surface deposited tons as the memo for ease of use

	From Feb 19 memo, (tons x000), current reserves	% of overall tailings	Scale up - Additional tons attributed to full Stage 2 buildout
Mill feed	983		
Tailings tons	6,918	100%	13,333
Backfill tons	3,805	55.0%	7,333
Tailings to Surface	3,113	45.0%	**6,000**
Acreage plan for Tailings footprint (acres) includes 23 acre existing pile	45.0		67.6

Calculations, estimates and assumptions
Section

No Action	- mine shutdown upon exhaustion of existing capacity - approximately in 2005/2006
Proposed Action	- using scale up numbers above- 7,333,000 tons to U/G, with 6,000,000 tons to surface
Alternative 1	Veneer scale up = (67ac)(43560 sq ft/acre)*(10ft)=29446560 cu ft/27 cu ft/cy = 1,090,613cy @ 1.81 tons/cy (whole tails) = 1,974,009 tons of tailings in veneer using plan view 67 acres, using slope area will add approx 5% KGCMC estimates a total expansion area of 45 acres (including existing 23 acres) will be utilized as a tailings footprint for the tonnages estimated for the data in the Feb 19, 02 memo At this estimated acreage for the current mine plan reserves, the expansion area has an average tons /per acre estimated of 69,177 tons/ac (3113K tons/45 acres) (23.7 ft height) and the scale up acreage of 67.6 acres has a 88,757 tons/ac (6000k tons/67 ac) (30.4 foot height), this higher unit/acre over the 45 acre plan is due to the increased pile height. These unit/acre averages will be used throughout this document.

	Tailings Footprint - acres	Veneer depth (Feet)	Coverage Volume (cubic feet)	Volume in cubic yards	Estimated tailings material density (tons /cy)	Tailings Tonnage associated with amended area	Percentage of weight used to calculate amendment tonnage	Amendment tonnage	Amendment total volume (cy) at amendment density	Estimated total tailings footprint acreage overall
Stage 2 scale up Tailings footprint	67.6	10	29,446,560	1,090,613	1.81	1,974,010	3.0%	59,220	70,500	69.0

Tables do not account for regular 3-5% cement addition to the Mine back fill

Alternative 1 - Option 1 - continuous carbon

Stage 2 Scale up	67.6					6,000,000	1.0%	60,000	71,429	69.1

Alternative 1 - Option 2 - carbonate veneer

Stage 2 Scale up	67.6	10	29,446,560	1,090,613	1.81	1,974,010	33.9%	669,189	487,037	77.5

Alternative 1 - Option 3 - continuous carbonate addition

Stage 2 Scale up	67.6					6,000,000	33.9%	2,034,000	1,480,349	97.8

Note: Scale up carbonate additions to the tailings area will constitute a $10.00/ton rock addition to the operating costs, so the scale up in Option 3 carbonate amendment will cost approx.
= (10.00$/ton)*2,034,000 tons = $20,340,000

Note ;590,013 tons of carbonate @101#/cu ft = 1.374 ton/cy
Therefore the volume = (Carbonate tonnage)/(1.374ton/cy)

Material Density Reference Table

Material	Density (ton/cy)	Density (#/cuft)	Density variance from tails	Volume for 1 ton of material (cu ft)	Volume variance compared to tailings
Tailings	1.81	134.2	0	14.9	100%
Carbonate	1.37	101.8	-0.44	19.6	132%
Pyrite	2.28	169	0.47	11.8	79%
De-pyrited tails	1.5	111.2	-0.31	18.0	121%
Carbon	0.84	62.4	-0.97	32.1	215%

Alternative 2

All Pyrite Concentrate to Surface without amendment : 6,720,000 tons

All De-pyrited tailings into Underground with (3,805,00 base) 7,334,000 (scaled up) ton capacity (based on density of whole tailings)

	Planned Tailings Production, (tons x000)	% of current mine reserve tailings	% of Pyrite Concentrate of the Tailings	% of De-pyrited Tailings from the tailings	Tonnage (x000) of Pyrite Conc	Tonnage (x000) of De-Pyrite Tailings	Volume (x000) cy of De-Pyrite Tailings	Underground capacity cy (X000)	Volume (x000) cy of De-Pyrite Tailings to Surface	Tonnage (x000) cy of De-Pyrite Tailings to Surface	Area required for De-pyrite tailings on surface	Tonnage (x000) Pyrite Conc to Surface	Tonnage (x000) De-pyrited Tails to Underground	Acreage on Surface for pyrite cons	Surface acreage factor for Pyrite Concs on surface	Acreage on Pyrite Storage on Surface with increased acreage factor	Total acreage
Scale Up Tailings	13,333	192.7%	49.6%	50.4%	6,613	6,720	4,480	4,052	428	642	8.7	6,613	6,077	59.1	2.0	118.3	127.0

Assuming for Feb 19 Memo tonnages, that 3,805,000 tons is the maximum void space available for underground storage

Assuming for Scale Up tonnages, that 7,334,000 tons is the maximum void space available underground

Pyrite storage assumptions

Surface storage estimates for a pyrite concentrate long term facility includes these assumptions:

-surface cell area needed to close (cap) a years supply of pyrite conc production is estimates at 4.6 acres, based on a 500ft*400ft pad to accommodate an 80' pile at 3:1 slopes

-based on utilizing half the cell per year, KGCMC would have to maintain 3 sets of 4 open placement cells per year due to placement criteria(cell and pore water dissipation, weather dependent placement and

-capping sequences rotation of 1 open, 1 foundation base being built, 1 being capped, and 1 ready for second lift. Also, based on assumption that the outer slopes and original foundation slopes must accommodate milder than 3:1

-due to building of lifts on top of liners, which will significantly reduce the height of the overall pile. Also, the need for a flatter starting foundation as the current steeper 3:1 outer pile slopes will not accommodate an underliner to place a pyrite conc onto.

-Therefore, an acreage increase factor of 2 will be applied to all Pyrite Concentrate storage on the Surface.

Alternative 2 - Option 1 - All pyrite concentrate placed underground, de-pyritized tailings placed u/g to fill capacity, remaining de-pyritized tailings to surface

	Planned Tailings Production, (tons x000)	% of overall tailings	% of Pyrite Concentrate of the Tailings	% of De-pyrited Tailings from the tailings	Tonnage (x000) of Pyrite Conc	Tonnage (x000) of De-Pyrite Tailings	Tonnage (x000) Pyrite Conc to Underground	Underground capacity cy (X000)	Volume of pyrite conc placed underground	Remaining Capacity u/g for de-pyritized tailings placement	Tonnage (x000) de-pyrited Tails to U/G	Cement % for stability only	Tonnage (X000) cement added to cons	Tonnage (x000) overall to U/G	Tonnage (x000) de-pyrited Tails to Surface	Acreage on Surface for whole tailings
Scale Up	13,333	192.7%	49.6%	50.4%	6,613	6,720	6,613	4,052	2,901	1,151	1,727	10%	834	9,174	4,993	67.9

Alternative 2 - Option 2 - Place pyrite concentrate underground with limestone amendment, remaining pyrite concentrate to surface in cells unamended, all de-pyritized tailings to surface

	Planned Tailings Production, (tons x000)	% of overall tailings	% of Pyrite Concentrate of the Tailings	% of De-pyrited Tailings from the tailings	Tonnage (x000) of Pyrite Conc	Tonnage (x000) of De-Pyrite Tailings	Tonnage (X000) limestone addition	Volume pyrite cons cy (X000)	Volume limestone cy (X000)	Underground capacity cy (X000)	Percent of amended cons u/g	Tonnage (X000) cons to u/g	Tonnage (X000) limestone added to cons	Tonnage (X000) cement added to cons
Scale Up	13,333	192.7%	49.6%	50.4%	6,613	6,720	6,538	2,947	4,759	4,052	52.6%	3,477	3,383	686

tonnage (X000) cons to surface	Surface acreage required for cons	Tonnage (x000) of De-Pyrite Tailings to Surface	Area required for De-pyrite Tailings	Total Area required
3,136	56.1	6,720	62.7	118.8

Option D 3

KGCMC has no information to supply on this option as no realistic off site disposal options exists at this time.

Calculations Support for scale up to Stage 2 design capacity

From Keith Marshall's Memo dated Feb 19, 2002

The numbers in the memo reflect current mine reserves and must be scaled up to reflect the potential storage capacity of the Stage 2 expansion.
The Stage 2 tailings facility was designed to hold a minimum of 6 million tons of tailings materials over the current existing pile. This design reflects potential development of additional reserves past the current mine plan estimate of the next 12 years. Scale up utilizes the same distribution of backfill tons and surface deposited tons as the memo for ease of use

	From Feb 19 memo, (tons x000), current reserves	% of overall tailings	Scale up - Additional tons attributed to full Stage 2 buildout
Mill feed	983		
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Calculations, estimates and assumptions

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	Tailings Footprint - acres	Veneer depth (Feet)	Coverage Volume (cubic feet)	Volume in cubic yards	Estimated tailings material density (tons /cy)	Tailings Tonnage associated with amended area	Percentage of weight used to calculate amendment tonnage	Amendment tonnage	Amendment total volume (cy) at amendment density	Estimated total tailings footprint acreage overall
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Tables do not account for regular 3-5% cement addition to the Mine back fill

Alternative 1 - Option 1 - continuous carbon

Stage 2 Scale up	67.6					6,000,000	1.0%	60,000	71,429	69.1

Alternative 1 - Option 2 - carbonate veneer

Stage 2 Scale up	67.6	10	29,446,560	1,090,613	1.81	1,974,010	33.9%	669,189	487,037	77.5

Alternative 1 - Option 3 - continuous carbonate addition

Stage 2 Scale up	67.6					6,000,000	33.9%	2,034,000	1,480,349	97.8

Note: Scale up carbonate additions to the tailings area will constitute a $10.00/ton rock addition to the operating costs, so the scale up in Option 3 carbonate amendment will cost approx.
= (10.00$/ton)*2,034,000 tons = $20,340,000

Note ;590,013 tons of carbonate @101#/cu ft = 1.374 ton/cy
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Pyrite	2.28	169	0.47	11.8	79%
De-pyrited tails	1.5	111.2	-0.31	18.0	121%
Carbon	0.84	62.4	-0.97	32.1	215%

Appendix C

Offsite Pyrite Disposal Assessment, April 26, 2002

The McDowell Group has investigated the cost of disposal of pyrite concentrate from the Kennecott Greens Creek Mine at a hazardous waste disposal facility in the Lower 48. One preliminary cost estimate has been obtained, that from American Ecology's hazardous waste disposal facility in Grand View, Idaho. American Ecology's Idaho facility has worked with Alaskan companies before in disposal of hazardous waste.

American Ecology estimated that transport of the pyrite concentrate from the Port of Seattle to Grand View, Idaho would be approximately $1,800 per 20-ton load, depending upon how the concentrate was packaged. This cost, combined with an estimated cost of approximately $1,500 per load for shipment from Juneau to Seattle[1], suggests a total shipping cost of $3,300 for 20 tons of concentrate, or $165 per ton.

If the concentrate meets "direct disposal" standards, the cost of disposal would be $40-$50 per ton. If additional treatment is required to stabilize for heavy metals, the disposal cost would approximately double.

The total cost for transportation and direct disposal of 2 million tons of pyrite concentrate[2] would be approximately $420 million. This estimate is based on a disposal cost of $45 per ton. If this volume of material is produced over an fourteen-year period, annual shipping and disposal costs would average approximately $30 million, an expenditure that would undoubtedly eliminate any possibility for profitable mine operations. According to Greens Creek managers, the mine currently has annual cash operating costs of approximately $50 million. A $30 million annual expenditure would increase annual cash costs by 60 percent. Though gross revenues vary with metal prices, based on current prices, production rates and estimated recovery rates, the mine may earn $70 million annually in gross revenues.[3] The cost to transport and dispose of the pyrite concentrate would completely eliminate the mine's gross profit (gross revenues less cash costs), let alone whatever profit the mine might enjoy after depreciation and amortization.

Additional research, which could include identifying other disposal sites and securing other disposal cost estimates, would be unlikely to produce findings substantially different than outlined in this preliminary report. Other suitable disposal sites likely exist, but none in closer geographic proximity to Alaska than American Ecology's Idaho facility. Therefore even if a site with lower disposal charges

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[1] McDowell Group estimate based on data provided by Southeast Alaska barge lines.
[2] Pyrite concentrate tonnage estimate taken from April 16, 2002 memorandum from Keith Marshall to Eric Ouderkirk.
[3] McDowell Group estimate.

were found, higher transportation costs would likely offset any potential savings. Similarly, the shipping costs cited here are preliminary, however no meaningful change in the magnitude of the cost to ship and dispose of the pyrite concentrate would be expected to result from additional research. A 20 percent change in shipping costs, for example, would change overall disposal costs by approximately 15 percent, or about $5 million annually. Even if annual disposal costs were in the range of $20 million to $25 million, the fundamental conclusion of this analysis is unchanged.

Finally, the McDowell Group's research clearly supports the assertion that pyrite concentrate has very little to no value in North America and that the environmental costs associated with processing it can be high. Some countries continue to use pyrite as a feedstock for producing iron ore or sulfuric acid; however, this is declining. Today, most sulfur is produced from H_2S gas recovered from natural wells. Moreover, the energy required and air pollution caused by the processing of sulfides for sulfuric acid production are substantial. The process requires burning or oxidizing the sulfide minerals, and utilizes significant amounts of water, fuel, and electricity and can create considerable air pollution. The resulting cinder is more likely to produce acidic leachate than the tailings and would have to be disposed of safely.[4]

[4] See http://www.dnr.state.wi.us/org/es/science/mining/pubs/faq/faq.htm#top.