June 4, 2013

Office of Environmental Information
U.S. Environmental Protection Agency
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Re: Docket #EPA-HQ-ORD-2013-0189

From: Kendra Zamzow, PhD

I appreciate the opportunity to comment, and have focused my comments primarily on the sections of the assessment dealing with ore and mine water chemistry, my areas of expertise. I am familiar with the biogeochemical processes that occur at mine sites and impact waters, and am familiar with mine water mitigation and treatment techniques. I have a PhD in Environmental Sciences and Health/Environmental Chemistry, am a member of the International Mine Water Association and the American Chemical Society, and am a peer reviewer for the journal Mine Water and the Environment. I have lived in Alaska since 1986, and have conducted water quality sampling in the Bristol Bay and Lake Clark regions.

GENERAL COMMENTS

Comments may have supporting discussion in indented paragraphs.

1. This second external review draft was developed after receiving public and peer review comments on the first draft of the Bristol Bay Watershed Assessment ("Assessment"). One theme of reviewers was the difference between mining permit timelines and the timeline of the risk assessment. The discrepancy is discussed in detail in this draft.

> The Pebble deposit is a very low grade ore, with developers using a cutoff grade of 0.3% to quantify the ore tonnage. What this means is that a small mine will not be economical. It is also in the top 5% of known copper porphyry ore deposits, meaning it will be a world class mine with a world class volume of waste material. EPA uses three scenarios that represent not possible mines, but rather stages of mine development to the full extent of ore that could be extracted through an open pit method.
>
> If a mining permit application is submitted for a 20-year time scale, regulators would assess this environmental risk. But mining this deposit requires expansion to be economic; shareholders would not allow a business to spend billions to develop the infrastructure for a mine and leave the bulk of the minerals underground. This Assessment realistically examines the build out of an open pit based on a small initial mine (0.25 billion tons, possibly the size of additional mines in surrounding claim blocks that could be developed after infrastructure is in place), a 20-year mine (2 billion tons, appropriate for a mining permit application), and a mine that would extract the known Western ore deposit of 6.5 billion tons (the full environmental risk). This is important information for regulators, stakeholders, and investors.

Notably, the Assessment is conservative by not including the additional risks of the remaining 4.5 billion tons of ore that could be extracted through underground mining once an open pit has reached the level of this deeper ore body in the Eastern part of the deposit.

2. Another theme from reviewers was that not enough attention had been paid to the impacts of day-to-day operations. This draft discusses the contaminant sources present in routine operations and the process for determining what sources and constituents were really important.

> Chapter 8 notes that waste rock and tailings water will percolate into permeable soil from unlined facilities. The chronic impact of uncontrolled copper seepage as a critical source of contamination during daily operations is detailed (Section 8.2). Leachate containing copper will upwell in a constant trickle, impacting miles of river by depleting invertebrates that fish rely on, causing fish to avoid or become incapable of sensing natal streams, reducing reproduction and causing acute toxicity (Tables 8-22 to 8-24). Impacts will be dependent on the rate of dilution and on copper loading into aquatic systems over time.

3. This draft synchs the mine stages with the chronic release of copper (through daily un-captured leachate) to show how the physical habitat and water chemistry risks increase as the mine expands.

> All three stages have some risks in common: an open pit that would become a pit lake, an unlined tailings dam that seeps and is at risk of slumping, unlined waste rock piles that leach contaminants. The risks increase at every stage, as shown through maps (e.g. Figures 6-1 to 6-3, Figures 6-8 to 6-10) and discussion that illustrate the changing landscape.
>
> Eventually, waste rock piles expand outside the cone of depression, delivering leachate into the landscape instead of flowing towards the mine pit. Leachate volume increases. The South Fork Koktuli is not at risk of receiving any tailings leachate until the Pebble 6.5 scenario, when the need for more tailings storage puts two facilities in this drainage. The Upper Talarik does not directly receive any leachate until the Pebble 6.5 scenario, when it will receive acid and non-acid leachate from expanding waste rock piles.

These physical and chemical impacts are critical to understand – the risks from the full build out of mining this deposit are distinctly greater than the risks that would be evaluated in an initial mining application covering the first few decades of a mine.

This Assessment provides a forum within which the public can examine how the risks change over the life of a mine based on the known ore body and physical, chemical, hydrological, and biological components of the area. This Assessment also clearly shows the potential landscape impacts of development of a mining district (Figure 13-1 and others), given exploration that is already underway and the clear intent of the State of Alaska to designate mining as a priority use.

The approach taken by the EPA provides reasonable bounds to the potential risks, and is a reasonable and very welcome complement to the EIS process.

CLARIFYING QUESTIONS

4.2.3 Overview of the mining process

1. Could you add a brief explanation as to why dry stack tailings is inappropriate for acid-generating material? Would dry stack be an option if a pyrite concentrate were produced, removing much of the sulfide-rich material?

2. Although accurate, the phrase *"Waste rock is stored separately from tailings"* might be better phrased as *"Waste rock is boulder to rubble-sized material that is placed in large, terraced stockpiles while tailings are a fine slurry material remaining after processing and require a different manner of storage."*

Table 6-2. Mining scenario parameters

1. It is not clear why the P02.5 scenario uses a very low mill rate, extending the period of mining to 20 years – this might be a good place to state the assumptions that were made.

2. Can you explain why the ratio of PAG to NAG waste rock moves to a much higher ratio of PAG between P2.0 and P6.5 scenarios?

Table 6-9. Stressors

Has anyone evaluated whether warmer temperatures in streams and an increase in TDS and potentially in selenium and nitrogen could trigger algae blooms (even if phosphorous does not increase)?

6.1.2.4 Tailings storage facilities

Please explain why it is assumed that the tailings dam will start out as a downstream-construction method (the most stable) and move to a centerline-construction method (less stable) as the TSF grows.

6.2.1.3 Mine scenario footprint, P6.5

This suggests moving PAG waste rock into mined-out parts of the pit for storage to minimize the PAG waste rock outside the cone of depression. Has this been done at other copper porphyry mines?

6.3.4 Closure and post-closure site management

If NAG waste rock piles are reclaimed, why would they be weathering?

> *"We assume that the mine would be closed after all economically profitable ore is removed from the site, leaving behind the mine pit, NAG waste rock piles and TSFs. Water at the site would require capture and treatment for as long as it did not meet water quality standards. Weathering of the waste rock and pit walls would release ions of potential concern, such as sulfates and metals."*

8.2.3.6 Spatial distribution of estimated effects

Under Pebble 0.25 Scenario Routine Operations, North Fork Koktuli, NK199A should be NK119A.

SPECIFIC COMMENTS

In the notes below, I refer to the Pebble 0.25, Pebble 2.0, and Pebble 6.5 scenarios as P0.25, P2.0, and P6.5. An introductory phrase or comment is followed by a key point or supporting discussion.

MAPS, FIGURES, and BOXES

Executive Summary

1. The map of the scenario footprints (Figure ES-4) is quite good at displaying the footprint visually.

   It might be helpful to add another map of the location of the 6 deposits considered in the Cumulative Risks section immediately following.

2. Under the "Risks to Salmon Fisheries" section, loss of streams and wetlands under different scenarios --

   It would be helpful to also have the potential loss of additional streams and wetlands due to the reasonably foreseeable build-out of future mines added to the bullet list (currently listed on ES-25). This is more representative of the upper boundary of risk analyzed in the document.

Box 4-4. Block caving and subsidence

In the sentence *"This could lead to oxidation of the sulfide minerals exposed during mining operations and, depending on the hydrogeology, the potential generation of groundwater with elevated metals content from the mined area"* --

> It would be accurate to change the wording to *"the potential generation of groundwater with elevated **acid and** metals".* Mine workings water chemistry is likely to consist of acid, sulfate, and metals (based on Pebble East leachate chemistry) and represents a potentially severe long-term risk.

Figure 5-2. Subsistence harvest and harvest effort areas

It is difficult to distinguish harvest areas for salmon and those for other fish. These might be easier to see if

> a) Along river sections, lay the blue and yellow lines side by side where there is harvest for both
>
> b) The triangles and boxes on river systems were eliminated. Where triangles and boxes are heavily clustered, the location may need to be expanded if it is important to see the specific sites, or the area could just be generally colored in shades of yellow and blue (eg along the Lake Iliamna shoreline), similar to the shading scheme in Figure 5-3 or Figure 5-12.

Chapter 7. Mine footprint

I appreciate the detail that went into the maps of wetland/stream losses and maps of changes in hydrology across the Upper Talarik, South Fork Koktuli, and North Fork Koktuli along with the accompanying discussions explaining how these were derived; both were helpful and enlightening.

Table 8-19. Background copper concentrations

It would help if the title to this table reflected that this represents routine operations.

Appendix H, Tables 2 (Global grade and tonnage) and Table 3 (Annual consumption)

These tables showing Pebble's place within the world's copper porphyry mines should separate out the known and indicated resource from the inferred.

COMMENTS ON ORE CHEMISTRY and ORE PROCESSING CHEMICALS

4.2.2 Chemistry and associated risks of copper porphyry deposits

1. There was no mention in this section of precipitation of metals downstream in neutral pH waters.

> Precipitation of aluminum, iron, and manganese are mentioned later and could be referenced here.

2. It would help to clarify that the paragraph below refers to porphyry copper deposits worldwide, and that Pebble likely follows a similar sequence of zonation; I have not seen a discussion of the zones of alteration of this deposit.

> *"In general, the rocks associated with porphyry copper deposits tend to straddle the boundary between being net acidic and net alkaline…. Moving outward from the core to the ore shell and pyrite shell, pyrite abundance increases and NNP values become progressively more negative."*

3. I appreciate the clear, accurate description of the process of weathering, acid drainage and neutralization.

> This section could be clarified if you note that components in both ore and host rock are released when in contact with acid, and not just the mineral of economic interest. When mentioning the minerals released under alkaline conditions, molybdenum should be mentioned along with selenium and arsenic, given the concentrations of moly in the area and the toxicity of molybdenum to fish eggs.[1]

4**.** The report suggests that material with neutralizing potential ratio (NPR) of 1-4 should undergo further kinetic and geochemical testing, reasoning: *"This further testing and assessment are necessary because if neutralizing minerals react before acid-generating minerals, the neutralizing effect may not be realized"* (pg 4-5).

> The NPR is appropriately used as a screening tool, and it is reasonable to have material with NPR between 1 and 4 undergo further testing as a critical component of waste rock management. In addition, kinetic testing needs to be continued for decades before and during the operation of the mine.
>
> Long term kinetic testing could determine if concentrations stabilize over time. The humidity cell test (HCT) results showed extreme standard deviation from the mean in some analyte concentrations (Appendix H Table 4). Some of this is due to the early erratic concentrations in the first flushing periods; this is analogous to snowmelt or rain flushing accumulated oxidized material out of waste rock piles after cold or dry periods and could occur seasonally at the Pebble site. It is important to consider the flushing concentrations as well as the means.

5**.** This section should mention that the sulfide components of the rock also cause the release of sulfate, a component of total dissolved solids (TDS).

> As mentioned in a later section, controlling TDS has become a significant issue at the Red Dog mine, which is having difficulty attaining even the 1,500 mg/L TDS concentration allowed under their water discharge permit, due in part to the high TDS in runoff from waste rock.

6**.** It would be worthwhile to note that the acid generated through the acid rock drainage process is much more acidic and in no way comparable to the type of "acidity" that naturally occurs in wetlands and peat environments.

> It is the extreme excess of acidity that depauperates stream life more than the drop in pH, and causes streams to be unable to buffer changes in pH (natural or anthropogenic). Should a "pulse" of acidity flush into a stream – an event that could occur if a WWTP temporarily failed – the recovery of the stream is

[1] Eisler, R. 1989. Molybdenum hazards to fish, wildlife, and invertebrates: a synoptic review. USFWS Biological Report 85, Contaminant Hazard Reviews, Report No. 19

based in part on catchment alkalinity. The South Fork and North Fork Koktuli have little alkalinity and are likely to have a difficult time rebounding from a pulse of acidity.[2]

	Peat	Acid Rain	Acid Rock Drainage
pH	3.5 to 6	4 to 6	-1 to 3.5
Acidity (mg/L $CaCO_3$ equivalents)	<1	2 to 4	110 to 64,000

Adapted from Kelly, M. 1988. Mining and the freshwater environment. Elsevier Applied Science, New York, NY 10017

6.4.2 Stressors evaluated

1. Concentrations at which metals are a concern to aquatic life were compared to the concentration of metals reported by PLP in tailings and waste rock leachate (Section 6.4.2.3) to determine which metals were most likely to pose a risk to salmon. Metals were not a concern if the ***average*** concentration in the leachate was below toxic concentrations.

This approach is conservative in that a) the methods used by PLP were flawed (e.g. used larger particles than the test method protocol) potentially underestimating the rate of release, time to onset to acid drainage, and metal concentrations in leachate; b) samples submitted for testing were not representative of the ore body and may not have captured alteration types typically found in hydrothermal mineralization (described in Appendix H) therefore the full range of leachate concentrations are not known; c) concentrations on the upper end may be observed on a regular, seasonal basis with flushing effects after cold or dry periods.

2. Dust from the tailings beaches, with pyrite and metals that could initiate chemical contamination in wetlands (reductive environment) and streams (oxidative environment) has not been considered in the stressors evaluation (Section 6.4.2.5). This stressor should be listed, along with mitigation options, particularly mitigation options that might be effective during winter's extreme cold when there are high winds.

Sodium Ethyl Xanthate

These comments refer to Sections 8.2.2.5, 8.2.3.2, and 10.3.3.3.

1. It is presumed that a spill of the ore processing chemical sodium ethyl xanthate will result in a fish kill, based on toxicity. Toxicity reportedly ranges from 1 ug/L (Australia and New Zealand, species not noted) to 50 mg/L (rainbow trout). This is a wide difference in toxicities, suggesting that studies with relevant species and life stages should be conducted.

2. The toxicity discussion may want to include the mechanism of toxicity or the effect on aquatic life, for both sodium ethyl xanthate and its breakdown product carbon disulfide. Also, the reference Hidalgo and Gutz 2001 is not a particularly good one for toxicity; better references would be the MSDS sheets and Alto, K, S Broderius, and LL Smith, Jr. 1977. Toxicity of xanthates to freshwater fish and invertebrates. University of Minnesota.

3. Is it possible that a spill of xanthate would not result in a fish kill if it occurred in winter onto frozen ground or on top of a frozen stream? Was this assessed?

[2] PLP, in fact, refers to the SFK alkalinity as "outside criteria" (lower than the "recommended" concentration in Alaska DEC water quality standards), although in fact the Alaska DEC wording is actually "20,000 (minimum) ug/L as CaCO3 except where natural alkalinity is lower". (ADEC 2008)

COMMENTS ON MINE SCENARIOS

1. The EPA has appropriately characterized the Pebble 0.25 (P0.25), Pebble 2.0 (P2.0) and Pebble 6.5 (P6.5) scenarios as mine stages. The P0.25 stage is not economically feasible unless infrastructure has been developed, but it provides the lower bounds of impacts. The upper boundary considered by the EPA is at the P6.5 stage. This is the likely limit of ore that can be developed through open pit methods. However, it is not entirely appropriate for the EPA to ignore the 4.5 billion tons of higher grade ore that could be accessed as the open pit nears the end of its life.

> The risks are not simply additive; there would be a lower stripping ratio and less waste rock on the surface with underground mining. The long-term risks depend on the mine method employed. Block caving will leave the entire mine area rubble-ized, exposed to water and oxygen as discussed in Box 4-4. This provides a potentially potent source for acid drainage, a realistic pathway to the surface, and a low likelihood of mitigation or remediation once started. Including an underground mine could both provide a more realistic upper bound to the risk scenarios, and provide a format within which to compare risks of alternative underground mining best practices.

2. Table 6-1 is helpful. The paragraph following the table generally describes the components of the mine that went into scenario development. The constraints on the waste rock and TSF locations are described well.

> The section could be strengthened by describing in more detail the constraints of the other elements: the size of the mine is constrained by the balance of metal prices and energy costs; the time period of mining is constrained by the mill rate and metal prices; ore transport off-site is constrained by volume and infrastructure options. Although the placement of TSFs are described as constrained by topography, they should also be constrained by hydrology and risks related to contaminant transport (Section 6.1.2.4).

It might also be noted that legally Lake Iliamna could be used for tailings disposal; it is the cheapest option but politically untenable at the present time. Box 6-1 is also helpful in clearly showing that the risks discussed in the mine scenarios are conservative at best.

3. Table 6-2 makes clear that processing 6.5 billion tons of ore results in about 22.2 billion tons of waste: 10.9 billion tons of NAG waste rock, 4.7 billion tons of PAG waste rock, and over 6 billion tons of tailings.

> Is there a way to show this visually, similar to the way the height of the TSF-1 dam is shown in Figure 6-4? Is there a way to show the total waste at each of the stages P0.25, P2, and P6.5, with the relative proportions of NAG waste rock, PAG waste rock, and tailings?

COMMENTS ON WATER CHEMISTRY DURING MINE OPERATION

1. PAG waste rock (section 6.3.3) will need to be managed during operations so that it remains accessible for blending into mill feed, while minimizing the risk that uncontrolled seepage from unlined waste rock facilities poses to waterways.

> Milling PAG waste rock reduces the long-term risk of PAG leachate entering water, but may increase the short-term risk by making it untenable to encapsulate PAG within NAG cells. There is an assumption that the onset of acid generation will not occur until 20 years after extraction, providing a safety factor for management (Section 6.1.2.3). If accurate, the critical period of concern would be between 20 years after the mine starts up (when rock would begin generating acid) and 20 years prior to closure (rock after that could be milled or submerged before it began generating acid); in the P6.5 scenario of a 78 year mine life, the greatest risks would be in mine years 20-58. Nearly four decades over which seepage would need to be completely collected and controlled – a near impossibility.

2. In reality, acid onset will occur over a range of years (PLP's own data estimates onset to acid ranges from one year to decades). In reality, there could also be intermittent closures over the life of the mine or premature closure (discussed in Section 6.3.5), leaving waste rock on the surface for longer periods of time than originally anticipated before final milling or submersion.

> This argues for continuing kinetic testing of multiple core samples representative of the entire ore body and hydrothermal alterations, and for continuing to collect and test core samples for decades as deeper deposits are accessed. Rock should be placed as safely as possible as if the mine might enter an intermittent closure in the future. This might require placing PAG waste rock on liners to reduce the seepage into groundwater, and placing lysimeters within waste rock piles to monitor changing chemistry, as has been done at Red Dog and other mines. Waste rock management plans should require that PAG rock never be outside the cone of depression, which may require processing PAG as the cone of depression at the end of mine life. PAG should be surrounded by NAG. Prior to permitting, a range of mitigation options should be presented along with known efficiency and failure rates at comparable mines.

3. The assumption that 50% of the leachate from the unlined waste rock piles will be captured (Section 8.1) should be supported by reference material or further substantiation.

4. Section 8.1 suggests that a wastewater treatment plant (WWTP) will meet water quality criteria, but Figure 8.1 suggests that even a fully functional WWTP will cause metals and TDS to increase below the plant.

> This is accurate, in that ambient water quality generally has lower concentrations (is better quality) than state water quality criteria, particularly relative to the quality of water in the North Fork Koktuli. It might be good to specifically state that discharge water that meets state criteria will cause metals and sulfate concentrations to increase in the rivers receiving the discharge.

	Baseline, South Fork Koktuli[a]		Baseline, North Fork Koktuli[a]		Water Quality Criteria (at 20 mg/L hardness)	Water Quality Criteria (Biotic Ligand)
	Range	Mean, Median	Range	Mean, Median		
Sulfate (mg/L)	0.6-90	9, 6	0.5-10	0.7, 0.7	250[b]	
Total Dissolved Solids (mg/L)	6-120	44, 40	4-126	37, 38	500[b]	
Zinc (ug/L)	0.6-27	3, 2	0.7 – 200	2.6, 1.4	32[c]	
Copper (ug/L)	0.1-20	1.7, 1.2	0.2 – 3.6[d]	0.4, 0.3	2.26 – 2.95[e]	1.5-2.4[f]

[a] Baseline data is from PLP 2012, Table 9.1-5 and Table 9.1-6; the high end of the range for zinc could be suspect and could drive the discrepancy between the mean and median.
[b] Alaska DEC 2009, standard for drinking water
[c] EPA 2013, Table 8-15
[d] PLP EBD tables of analyte concentrations show that on rare occasions copper could become elevated to near 3 ug/L, usually during the spring snowmelt; this appears to have occurred no more than once over the period of data collection at each North Fork Koktuli site. The concentration of 3.6 ug/L, the maximum recorded at the North Fork Koktuli, is unusual in that it occurred in February 2006 (Appendix 9.1B of Chapter 9 in the PLP Environmental Baseline Document, pdf page 644 of Chapter 9).
[e] Alaska DEC 2008 and EPA 2013, Section 8.2.2.1. Lower number is CCC (criterion chronic concentration), higher number is CMC (criterion maximum concentration)
[f] EPA 2013, Table 8-11. Lower number is CCC (criterion chronic concentration), higher number is CMC (criterion maximum concentration)

5. The TDS in the tailings leachate (Section 8.1.1.5, Table 8-9, Table 8-16, Table -17) seems low –

    Was the addition of lime in water treatment considered? Generally sulfate is near 2,000 mg/L in tailings water due to the addition of lime during treatment and the solubility limits of calcium sulfate. Why weren't Tables 8-16 and 8-17 developed for the Pebble 2.0 scenario? Why is selenium not listed in Table 8-15?

6. Tailings pore water during mining operations is presumed to reflect that shown in humidity cell tests.

    This may not be accurate if cyanide is used to remove gold. Cyanide in pore water is associated with keeping copper and other metals in the dissolved form and susceptible to increasing the copper concentrations in leachate (and the nitrogen inputs to receiving waters).

    The Assessment uses the mean of leachate tests, although these tests showed highly variable chemistry and used non-standard procedures (e.g. larger particle sizes than standard tests).

7. The discussion on analogous sites (Section 8.2.2.1) where dissolved copper is present and the combined copper, cadmium, and zinc concentrations affect insects even though concentrations meet water quality criteria is interesting and relevant.

    The South Fork Koktuli is not really a "river" at the headwaters in the area of the deposit, it is more an assemblage of tiny tributaries moving toward a low point just above Frying Pan Lake. Some tributaries do have elevated copper, while others do not.[3] Additionally, some of the elevated metal concentrations occur only during the "first flush" at snowmelt or rains. And as with the analogous sites, most of the water in rivers draining the Pebble deposit would see an increase in sulfates and metals even if WWTP effluent met water quality criteria at the point of discharge.

[3] At my sampling stations, the tributary site SK-31 on top of the ore body in June 2009 and June 2010 had elevated copper at 4.4-5.3 ug/L. However, nearby tributary site SK-51 did not have elevated copper (1.3 ug/L, sampled only in June 2010), nor did the nearby main-stem site SK-02 (1.5 ug/L sampled only in June 2010) (Zamzow 2011).

COMMENTS ON FAILURE SCENARIOS

Transportation Corridor Failures

The assessment for truck-related spills was conducted by extrapolating from truck trips at the Pogo gold mine (Section 10.3.3.1). Would it have been more appropriate to base the assessment on a copper porphyry mine?

Pipeline Failures

These comments refer to Chapters 6, 11, 14.

1. Why is the risk of pipeline failure presumed to be adequately reduced with double-walls where the pipeline is above ground, but a single-walled pipeline appears to be adequate when buried below ground (Section 6.1.3.2).

> Given the groundwater-surface water exchange, a pipeline failure below ground has the potential to contaminate surface waters; a double-walled pipeline for sections below ground would reduce the risk.

2. With respect to Figure 11-1 (concentrate), it is not clear what the box "Product Recovery" refers to.

3. The three models (Figures 11-1 to 11-3 for concentrate, return water, diesel) should have included routes that lead to "no effect" on salmon (e.g. spills on land or on frozen creeks), or should have been described as models specific to a spill at sites such as Chinkelyes Creek or Knutson Creek which flow year-round.

> In the Integrated Risk section, Table 14-1 specifically notes that most pipeline failures would not affect fish, but this message did not come through in Chapter 11, although it was mentioned (Section 11.3.2).

4. The rate of spills per year seems low – does it include the probability of a spill in a "no effect" area (no stream or frozen stream)? The spill rate might be better presented as a range of potential failure rates, including rates by wall thickness (which is expected to vary in the concentrate pipeline).

5. It would be helpful to provide a route map with locations where a spill would represent high risk to salmon.

6. There should be a discussion that compares the spatial and temporal effects of the three types of spills.

> Spatially, a concentrate spill could cause fish aversion and the effective loss of the entire stream above as well as below a spill (Section 11.3.4.4), but this would not be the case for diesel, where only the reaches below a spill would be lost due to toxicity. Temporally, downstream of both types of spills could be lost for many years, due to leaching of copper from concentrate or the generational toxicity of PAHs.[4]

7. It could be difficult to follow the risk characterization (Section 11.3) of concentrate product, product leaching, and aqueous phase product, although it was summarized well at the end. For example, it appears from the text that there will likely be acute toxicity in small streams from spills, but in large stream flows or in Lake Iliamna there is likely low or no impact, yet this is not clear from tables and concept models.

8. Section 11.4 on return water pipelines should include a discussion of spills in winter, both from an underground pipeline (Section 11.5 discusses this with respect to diesel) and from an above ground pipeline.

9. The diesel spill section (Section 11.5) should have included a discussion on the toxicity of weathered oil, and of the effect of chemical and mechanical dispersion as described in the Schein et al article, one of the references.

10. The reference to the Rice (2007) study in "Analogous Spills" (Section 11.5.3.4) is relevant, in that it tracked the toxicity of polycyclic aromatic hydrocarbons (PAH) over generations of salmon in freshwater habitat; PAH toxicity is common to crude oil and diesel oil spills.

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[4] Note that a 1,400-2,200 gallon spill has already occurred in the Iliamna River, with fuel being transported by Iliamna Development Corporation; the primary customer is PLP http://community.adn.com/node/148928; http://www.dec.alaska.gov/spar/perp/response/sum_fy09/090605201/090605201_index.htm

COMMENTS ON CLOSURE AND POST-CLOSURE ISSUES

Tailings

1. In Section 6.1.2 there is a discussion of post-closure tailings water. Tailings pore water (seepage) is expected to be similar to that of humidity cell leachate and tailings pond water is expected to approach the chemistry of ambient water.

> The humidity cell tests showed wide variability in chemistry (Appendix H), and using the mean may underestimate contaminant leachate.
>
> Ammonia and the cyanide breakdown product thiocyanate (if cyanide is used in gold processing) may remain elevated for years in tailings pond water.[5]

2. Tailings acid generation and dam failure will need to be prevented *in perpetuity*. A balance will need to be struck between drawing water down to relieve pressure on the TSF dam(s) and maintaining a water cover to reduce oxygen infiltration and acid generation (Section 6.3.2). Reducing the risk of dam failure inherently increases the risk of poor water behind the dam.

Pit Lake

Section 6.3.1 mentions that it is not possible to predict the long-term pit lake water quality. Given the completely uncertain long-term conditions, and the risks of seepage to aquatic life and potential risks of poor pit lake water quality on waterfowl, it is appropriate that EPA suggests long term monitoring and water treatment should be anticipated and bonded for.

> In addition to the uncertain efficacy of potential mitigation measures (such as pacifying the pit walls above the water line), microbial activity may influence the degree of acidity in the pit lake. For example, in a comparison of two lignite mining pit lakes, the difference in pit lake seasonal turnover may have created conditions that shifted the balance between oxidizing and reducing bacteria, thereby maintaining acid water at one pit lake and neutral pH water at another.[6]

However, as mentioned elsewhere, the pit lake will exist *in perpetuity*, and unless water quality reaches similar quality of surrounding waters, the risks could last longer than the human institutions available to manage them.

Roads

Another post-closure issue of concern is road maintenance, which will be needed to maintain the water treatment plant *in perpetuity*. The access road will need to continue to keep stream crossings open for juvenile and adult fish and minimize runoff into streams (Chapter 10).

> There will be an incentive to maintain the road if additional mines or induced development occurs, but little incentive if there is no further economic development beyond a single Pebble deposit sized mine.

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[5] Kwong, YTJ, A Kapoor, and J-F Fiset. 2002. Assessment of chemical stability of impounded tailings at Mount Nansen, Yukon Territory. CANMET Report MMSL 02-011 (CR).

[6] Meier, J, H-D Babenzien, and K Wendt-Potthoff. 2004. Microbial cycling of iron and sulfur in sediments of acidic and pH-neutral mining lakes in Lusatia (Brandenburg, Germany). *Biogeochemistry* 67: 135-156.

RECOMMENDATIONS For MITIGATION

Within the report, specific protective options and practices were mentioned or discussed that could reduce or mitigate the risks. Any future permitting should consider these options, based on the risks detailed in this Assessment.

Water Treatment

- Apply a BLM-based criterion for copper and potentially for cadmium and zinc, based on the ambient water quality below the WWTP outfalls. Consider more restrictive criteria than the BLM or Alaska water quality criteria if necessary to be protective.
- Consider at a minimum the additive effects of metals in mixtures.
- Require water quality criteria to be met at the point of discharge (no waivers or mixing zones).
- TDS discharge limits should consider the sulfate likely to be generated from the WWTP process as well as from waste rock leachate, and be based on relevant testing that includes fish egg fertilization. Limits should consider the particular mix of ions likely to be dominant.
- Regular biological and ecological monitoring should be conducted. Biological monitoring stations should not be eliminated or moved further from the point source of discharge as discharge permits are renewed.
- Wastewater treatment discharge flow should be required to match seasonal flow cycles to prevent higher than natural flows into the system, channelization, and scouring. This should require maintaining capacity for stormwater to be collected and meted out, particularly with a view to prevent “common mode” failures.

Waste Rock Leachate Mitigation

- Permits should presume that PAG will not be completely separated from NAG, and base models of waste rock leachate on this presumption.
- Require liners under the waste rock piles.
- Require lysimeters and temperature monitors to be placed during waste rock pile construction.
- PAG should be processed throughout the mine life and all of it processed at the end of mine life.
- PAG should be surrounded with NAG waste rock.
- Keep PAG rock within the cone of depression.

Tailings Mitigation

- Kinetic testing of numerous representative ore body samples should be required throughout the life of the mine, based on standard test procedures; testing methods and data need to be available to regulators.
- A pyrite concentrate should be produced.
- If dry stack tailings are produced, pyrite should be removed to the extent that is technically feasible, and liners should be placed under the stacks.
- If tailings are stored in an impoundment, require the impoundment to be lined.

- If tailings are stored in an impoundment, require dams to be constructed in the safest possible manner, e.g. downstream method.
- Mitigation of tailings dust, particularly in winter, should follow current and evolving best practices over the life of the mine.

Spill Mitigation

- Double-walls and protective pipeline thickness should be required on the entire length of concentrate and diesel pipelines
- Stipulations on pipeline design and maintenance should consider pipeline life as the likely entire life of the mine based on the ore deposit size, not in the initial mining permit application.
- Consider testing xanthates on relevant species and life stages, and test degradation conditions and toxicity of degradation products per the potential toxicity of a spill or of tailings leachate.

Roads and other Site Mitigation

- Leachate collection needs to be in place wherever waste rock, including NAG, is used in construction of mine facilities.
- Bridges or embedded culverts should be used, and road crossings should follow current and evolving best practices over the life of the main to maintain migratory corridors for juvenile and adult fish and prevent hydraulic changes. Road maintenance needs to use the best technical practices, without regard to economics, to keep sediment, salts, hydrocarbons, antifreeze, and other transportation-related material out of streams, and bonding needs to be sufficient for good road inspection and maintenance *in perpetuity*.
- Consider testing concentrations of calcium on relevant species and life stages per the potential toxicity of road salt runoff.

Thank you for the opportunity to comment on the Second Draft Assessment.

Sincerely,

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