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Richard L. Darden
Regulatory Division
U.S. Army Corps of Engineers
P.O. BOX 6898
JBER, AK 99506-0898

January 25, 2017

Subject: Follow up on Donlin Technical Working Group meetings, December 2016

Dear Mr. Darden;

The Chuathbaluk Traditional Council has read and approved the attached comments written by Kendra Zamzow, and David Chambers, on behalf of Chuathbaluk as a follow up to the Donlin Technical Working Group meetings in December 2016. We anticipate that these will be reviewed and incorporated into the Alternatives as appropriate.

If you have any questions or concerns regarding our request and data gap concerns, please feel free to contact the Chuathbaluk Traditional Council at (907) 467-4313 or via email at ctc.patriciayaska@gmail.com

Sincerely,

Patricia Yaska
Brownfield Tribal Response Program Coordinator

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"Technical Support for Grassroots Public Interest Groups"

MEMORANDUM Date: December 23, 2016

From: David M. Chambers

To: Corps/AECOM

Re: Donlin Technical Meeting on Mine Water and Tailings Storage Facility

During the meeting on Tuesday, December 13, 2016, there was a short discussion on the potential use of blanket or other drain-designs to drain the tailings in the impoundment, as per the recommendations of the Mt Polley Expert Panel.

During that discussion a comment was made by either the Army Corps Subject Matter Expert, or a consultant (I am not able to identify the individual), that 'tailings always remain saturated.' The expert was then asked about tailings impoundments in arid areas like Arizona and New Mexico, and his response was that those impoundments are dewatered by 'suction created by surface evaporation.'

There is quite a bit of literature detailing the success of drains for controlling the phreatic level in tailings dams using toe drains of several designs, and of the success of dewatering the entire tailings mass itself – primarily for uranium tailings.

A search for references to evaporative dewatering of tailings impoundments did not turn up any definitive articles on dewatering an entire impoundment, only reference to dewatering rates due to evaporation in the upper meter of tailings, and references to using thin-layer deposition or the addition of flocculants to increase evaporation. None of these techniques are documented as being used in arid areas to dewater tailings impoundments. There is documentation of extensive sulfate plumes in groundwater downgradient of copper tailings impoundments in arid areas, proof that interstitial water is entering (i.e. draining) into groundwater in significant amounts.

Existing literature supports the concept that tailings can be drained by drain layers, especially since this concept is essential to controlling the phreatic zone for tailings dams.

The Army Corps should ask for references that support the statement that 'tailings always remain saturated' as purported in the December 13 discussion, since the failure to consider draining the tailings post-closure depends on this assumption/assertion.

I would be happy to have a discussion with the subject matter expert/consultant about the recommendations of the Mt Polley Panel, and their potential for implementation at the Donlin tailings impoundment.

Sincerely;

David M Chambers

David M Chambers, Ph.D., P. Geop.

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CSP²

December 18, 2016

Chuathbaluk Tribal Administration
#1 Teen Center Trail
Chuathbaluk, AK 99557

Re: Follow up on Donlin Technical Working Group meetings, December 2016

Dear Patricia and Tracy:

I would like to recap here the key issues that appear to remain unresolved after the technical working group (TWG) meetings of December 12-16. I think it would be useful if you could combine these comments with comments of your own from the Barging TWGs and send to the Army Corps of Engineers as a follow up to the meetings. It might be helpful if our thoughts were laid out as

- Unresolved concerns that require additional field work or modeling. For these, we can request RFAIs (official "request for additional information")
- Unresolved concerns that require clarification in the next draft (or final) EIS

My key concerns revolve around

- The toxicity of pit lake surface water to wildlife, especially migratory waterfowl. This is affected by the volume of contaminated water from the WRF, the volume of clean surface and groundwater, and how they mix.
- The potential for pit lake water at depth to move out of the pit and transport contaminants.

Following is a list of RFAIs and requests for "clarification and context", followed by a more detailed discussion.

Please do share any of my memos with the traditional council. As you know, my goal is to ensure that all risks have been adequately identified and mitigated to the extent possible, and to ensure the Chuathbaluk Traditional Council has good information on which to base any future decisions or input they would like to provide in the process.

Regards,

Kendra Zamzow, PhD

RFAIs

This is a list of RFAIs we are requesting. The context for them follows in the bulk of the letter.

Waste rock covers

RFAI: How would placing an impermeable cap over PAG cells compromise the integrity of the WRF? How would placing an impermeable cap over the entire WRF compromise it?

RFAI: If an impermeable cap was placed on PAG cells in the WRF or on the entire WRF, would pit lake overturn occur sooner? Would pit lake water be "less bad" than with the designed colluvium cap? How would this affect water treatment plant design or capacity? Could it lead to decommissioning of the water treatment plant?

RFAI: In an early closure scenario, could an impermeable cap on PAG cells or the entire WRF eventually eliminate the WRF seepage into the pit lake allow the pit lake water to "clean up" enough (through clean freshwater inputs) that the water treatment plant could be closed? If so, provide an estimate of the number of years until the plant could be closed if the mine ended operations after 5 years, 10 years, 15 years. Please compare the cost of an impermeable liner over the full WRF to the cost of water treatment over these time periods.

Pit lake ecotoxicity

RFAI: Determine the toxicity of overturn pit lake water to wildlife, including waterfowl.

Groundwater hydrology

RFAI: Provide information on the feasibility of utilizing deep exploratory holes to determine the existence or non-existence of regional groundwater flow.

RFAI: Provide suggestions on other methods of collecting solid data that would inform the question of and models of regional groundwater flow.

Water treatment

RFAI: Please provide case studies of mines using xeolite to remove arsenic at similar scales.

RFAI: Provide water quality for the DSTF operating pond, and apply that to a "water only" spill release scenario for Alternative 5A.

RFAI: Please explain what the difficulties are, what technology exists, and limitations for treating DSTF operating pond and pit lake water, such as the volume that can be treated and discharged and placement of waste that cannot be discharged.

Mercury

RFAI: Please ensure soil and sediment samples utilized to determine mercury methylation are proportionally representative of the landscape to ensure there has not been any sampling bias.

RFAI: Perform laboratory tests with sediment, applying future wastewater effluent simulations under a range of temperatures and dissolved organic carbon concentrations.

RFAI: Perform the same tests listed above with the simulated tailings.

RFAI: Determine the Hg(II) content of porewater in sediment.

RFAI: Adjust the fugitive gas emissions model to account for the percent of time with high solar radiation.

Clarification and context
These are items that we do not believe need an RFAI, but which deserve clarification or better description of context in the FEIS.

Clarification: Should a range of hydraulic conductivities be applied to determine WRF seepage rates and volume?

Context: If regional groundwater flow is identified, discussions of pit lake stratification, pit lake ecotoxicology, and the water treatment plant will need to be updated.

Context: If it is determined that the pit will not maintain hydrologic conductivity, this may require a new management plan for waste rock intended for backfill.

Context: If bedrock conductivity is higher than expected, will this have implications for desiccation of wetlands?

Context: In the event that high flow is encountered at depth while mining, what would an extra 500 m^3/hr or 1,000 m^3/hr look like when added to the contact water pond or other storage areas?

Context: Post-closure scenarios for Alternatives 2 and 5A should include cost and design for waste from the water treatment plant that cannot be discharged.

Introduction to concerns

Three features will remain on the landscape forever: the tailings facility (with the permanent risk of tailings liquefaction if the dam fails at any time in the future), the waste rock facility (which will leach arsenic, selenium, and other contaminants forever, if rain and snow are allowed to infiltrate), and the pit lake (which will receive the contaminated waste rock seepage).

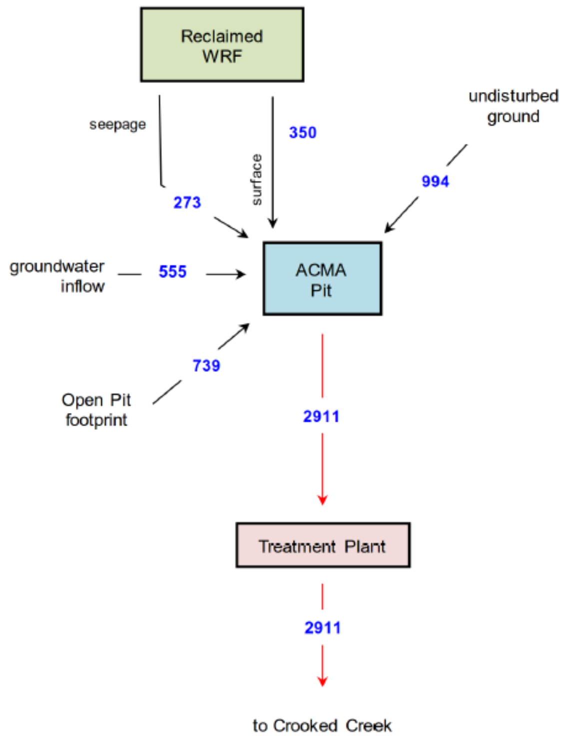


Figure 3.5-28 of DEIS. Flows (blue numbers) are in gallons per minute (gpm) expected in Years 52-200 of closure. Red arrows denote pumping routes; however, the route for "seepage" from the WRF will be a mix of gravity flow and pumping and perhaps should be marked with a red arrow.

While there is an alternative to assess for tailings options, there is no alternative that eliminates the pit lake. It is a certainty. The only permanent inputs into the pit lake are the waste rock facility (WRF) seepage and clean runoff water/precipitation (Figure 3.6-9). The tailings facility (TSF) is expected to stop contributing after the 30-60 year draindown period.[1] Groundwater may move into the pit in quantity (Fig. 3.5-28), but there is currently a lack of data supporting the conceptual model describing over 500 gpm groundwater flowing into the pit and no groundwater flowing out.

The environmental risks that require analysis under NEPA are

- The toxicity of pit lake surface water to wildlife, especially migratory waterfowl. This is affected by the volume of contaminated water from the WRF, the volume of clean surface and groundwater, and how they mix.
- The potential for pit lake water at depth to move out of the pit and transport contaminants.

Pit lake water quality

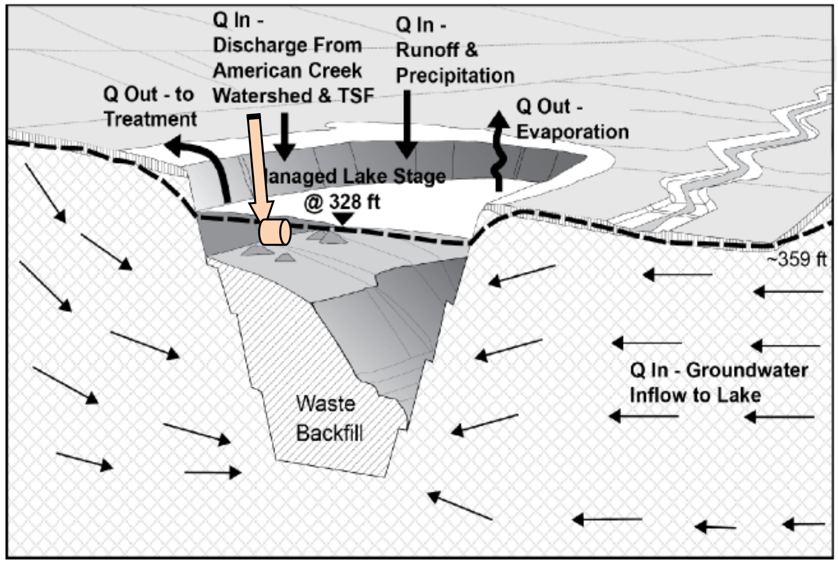
Waste rock seepage – very high in total dissolved solids, arsenic, and other contaminants, will enter a rock drain under the WRF and flow towards the pit. At the pit rim, it will be pumped to the bottom of the pit; presumably it will be pumped to the depth immediately above the waste rock backfill, rather than 1,800 feet down to the actual pit bottom. Freshwater inputs will float on this saline seepage water; this

[1] There is expected to be about 400 gpm clean groundwater flow (Fig. 3.5-28 and p 3.6-38, DEIS) to dilute the 18 gpm allowed to seep through the TSF liner, and therefore any water that infiltrates and percolates through the TSF cover is not expected to be poor quality.

stratification is a key part of the mine "design for closure" and a key argument to why the WRF should not be lined or provided with an impermeable cover.

This "less bad" surface water is the water quality utilized to determine if the pit lake water would be toxic to wildlife, and to design the water treatment plant.

This is insufficient. The bad water on the bottom of the pit lake *will* eventually mix throughout the lake. The effect of this mixture on wildlife, and inputs that contribute to mixed lake water quality need to be assessed. Cooperating agencies should not trivialize this issue simply because it may not occur for 100-200 years after closure. While the mining company will be long gone, the people and wildlife will remain and fewer mitigation options may be available.



Adapted from Fig. 3.6-9 DEIS. The figure above shows the water inflows to the pit after closure. Added is a possible pumping discharge route for waste rock seepage (color). The tailings facility (TSF) is not expected to contribute water to the pit lake after the lake is full, and should be removed from the image.

WRF cover and pit lake water quality

The type of cover on the WRF influences the volume of bad water seepage that enters the pit. It also influences the year at which the pit lake will turn over (mixing bad saline bottom water with upper freshwater). A less permeable cover will lead to less bad water to the pit and a faster time to turnover.

The cover for the waste rock facility is designed as 3 feet of "low conductivity" (10^{-7} m/s) colluvium topped by vegetation. This will allow precipitation (rain, snowmelt) to enter into the waste rock. Water will be entrained in the waste rock facility before the cover is placed, and will continue to enter the facility, at a lower rate, after the cover is placed. Entrained and infiltrating water will percolate through the WRF into the underdrain and on to the pit. The permeable colluvium cap on the WRF ensures that water will percolate through the WRF in perpetuity and will seep into the pit lake in perpetuity.

Colluvium, which is uniformly given a hydraulic conductivity of 10^{-7} m/s in the DEIS, plays heavily into the WRF design. It was used to describe the conductivity of the 5-10 m of natural material under the WRF, the material that "encapsulates" PAG cells within the WRF, and the cover that will be placed on the WRF.

- Request for clarification: Even at depth, bedrock has a range of 10^{-6} m/s to 10^{-9} m/s. Shouldn't this range be applied to hydrology related to WRF covers? This could inform the seepage volume from the WRF, pit lake water quality, and the time to turnover.

PAG cells are expected to provide the worst water quality in the seepage, but make up a relatively small part of the volume of the total WRF. Most waste rock will by NAG, some of which will leach arsenic and some of which will not. Placing an impermeable cap on the PAG cells within the WRF or over the full WRF would limit oxygen moving into the facility (which would reduce reactions converting PAG rock sulfides to sulfuric acid/acid drainage) and reduce or eliminate water entering the PAG cells or WRF. We are told this would compromise the strength of the facility.

- RFAI: How would placing an impermeable cap over PAG cells compromise the integrity of the WRF?

- RFAI: How would placing an impermeable cap over the entire WRF compromise it? Or is the decision to go with an impermeable cap one of budget rather than geophysics?

The type of cap that covers the PAG cells and WRF affects pit lake water chemistry and potentially the point at which the water treatment plant needs to be redesigned to treat very bad water or the point at which a water treatment plant could be decommissioned entirely. It is critical to understand these points in order to balance long term cost and risk (water treatment) and short term cost (impermeable caps).

There is no reason to expect WRF seepage water chemistry to improve over time. When water levels flux with draindown and precipitation inputs, they create "wetting/drying" cycles that are particularly effective in causing metal leaching and mobilization.

- Add to FEIS: There are implications for the cost and design of a water treatment plant that is able to fully treat overturn water. If this requires reverse osmosis units, these themselves have solid and brine waste products. Post closure, the brine cannot be sent through the processing plant. Disposal of these waste products needs to be part of the full post-closure scenarios considered for Alternative 2 and Alternative 5A.

- RFAI: If an impermeable cap was placed on PAG cells,
    - Would overturn occur sooner? Would the chemistry of pit lake overturn water be "less bad" without PAG cell seepage? Would this make it easier for a water plant to treat?
    - Could a water treatment plant be fully decommissioned, and if so, at approximately what point in time (given inputs from fresh water, NAG WRF seepage, pit wall sloughing)?

- RFAI: If an impermeable cap was placed on the WRF,
    - Would overturn occur sooner (due to less TDS water entering the pit)? What are the implications for water treatment?
    - Is there a point at which the water treatment plant to be decommissioned entirely?

WRF cover and ecotoxicity of pit lake water

The models for potential toxicity of pit lake water only considered the scenario in which the fresher water was at the pit lake surface and the worst water was isolated below. We know that under the current design the bad water *will* eventually mix throughout the pit lake. The lack of an assessment of ecotoxicity after pit lake overturn is a serious data gap. The pit lake water at the point of overturn may not be the same as the Year 99 “complete mixing” scenario, as the pit lake may have a greater percentage of WRF seepage and less freshwater, resulting in potentially worse water than the Year 99 mix estimates.

- RFAI: Determine the toxicity of overturned pit lake water to waterfowl. For example, ecotoxicology was determined using arsenic at 114 ug/L (Lorax 2015 Table 3-1), but in an overturn scenario arsenic in pit lake surface water will be around 2.4 mg/L (Lori Filipek comment during TWG meeting). Discuss the potential ecological, technical, and cost impacts of mitigation options (e.g. drawing water from the bottom of the pit for treatment, etc.)

- For mitigation: If an impermeable cap was placed on the PAG cells, how would this change ecotoxicity?

- For mitigation: If an impermeable cap were placed on the WRF, how would this change ecotoxicity?

Early closure – cost of caps versus water treatment

We also need to keep in mind that water treatment will need to go forward, potentially in perpetuity, even if the mine only operates for a few years. Early closure, if permanent, is a particularly concerning scenario in that the water treatment plant will need to operate, possibly in perpetuity, but the mining company may have only paid into the fund for operations for a few years.

An early closure mitigation should consider an impermeable cap on any portion of PAG cells that have not already been covered by colluvium and non-acid generating (NAG) rock, and an impermeable cap on the full WRF. This would reduce the number of years that water flows out of the WRF into the pit lake.

- RFAI: In an early closure scenario, would eventually eliminating the WRF seepage into the pit lake allow the pit lake water to “clean up” enough (through clean freshwater inputs) that the water treatment plant could be closed? If so, provide an estimate of the number of years until the plant could be closed if the mine ended operations after 5 years, 10 years, 15 years. Please compare the cost of an impermeable liner over the full WRF to the cost of water treatment over these time periods.

A less expensive option to an impermeable liner over the full WRF would be to place the planned colluvium liner as a WRF cap but encapsulate the PAG cells in impermeable material.

- RFAI: In an early closure scenario, would eliminating seepage from the PAG cells alone be enough to allow the pit lake water to “clean up” eventually, or would arsenic leaching from NAG rocks continue to be so high that, along with contributions from the pit wall sloughing, freshwater inputs (clean runoff, precipitation, snowmelt) would not be enough to dilute the poor water and the pit lake would need water treatment in perpetuity? If decommissioning the water treatment plant is possible, provide an estimate of the number of years until the plant could be closed if the mine ended operations after 5 years, 10 years, 15 years. Please compare the cost of an impermeable liner over PAG cells to the cost of water treatment over these time periods.

Hydrology and the pit lake

There remain concerns as to whether a regional groundwater flow exists that could intersect the pit and whether bedrock groundwater will flow towards the pit at all depths after the pit has filled. These have implications for pit lake de-stratification, water quality, and transport of pit water contamination.

Does regional groundwater flow exist that could intercept the pit?
The concept that groundwater will flow towards the pit at closure, even when the pit is filled with water (leaving 33 feet of freeboard between the lake and the pit rim) is based on data collected almost entirely in the upper 400 feet of the geology. The model was developed without any hydrologic data from depth.

First, deep wells should have been drilled to collect this data. At the Pebble exploration site, over 20 wells between 1,000 and 5,700 feet deep were drilled for monitoring and study purposes.[2]

Is it possible to determine the presence or absence of regional flow without drilling new, very deep wells? There must be exploratory drill holes down to the suggested 1,800' depth of the pit, and probably somewhat deeper than that. Drill logs would show the type of geologic material at depth and potentially whether groundwater was encountered. These holes, if closed, would be expected to have cement in the alluvial material, to prevent a connection from groundwater to the surface; however, nearly all the depth (in bedrock) is probably not cemented. It could be relatively inexpensive to drill through the upper cement and conduct hydrologic testing.

- ➢ RFAI: Provide information on the feasibility of utilizing deep exploratory holes to determine the existence or non-existence of regional groundwater flow.

- ➢ RFAI: Provide suggestions on other methods of collecting solid data that would inform the question of and models of regional groundwater flow.

Regional groundwater flow as a factor in pit lake water
If groundwater does intersect and move in and out of the pit, this has serious implications for the assumption that pit lake water will remain stratified for at least 100 years. The assumption is based on models that feed high TDS waste rock facility drainage into the pit; if this high TDS water is intersected by fresh groundwater, stratification will be affected, with implications for the design of the wastewater treatment plant and the disposal of waste (for example, from the reverse osmosis waste). Additional groundwater inputs could also provide more dilution.

The following provide context to emphasize the importance of understanding groundwater hydrology.

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[2] DNR 2016 PLP Borehole Status spreadsheet

- If regional groundwater flow is identified, the pit lake stratification modeling will need to be adjusted.

- If pit lake stratification modeling is adjusted, a complementary adjustment of pit lake ecotoxicology, particularly for waterfowl, needs to be conducted.

- If regional groundwater flow is identified, a discussion of the water treatment plant will need to be updated. This should be done for Alternative 2 (TSF option) and Alternative 5A (Dry Stack Tailings Facility option). It will need to discuss design features such as the type and volume of water to be treated, and disposal of water treatment waste that cannot be discharged to creeks.

Pit lake water quality mitigation
Whether or not there is regional flow, there is possibility that water will not remain in the pit at all depths. Determining the depth at which flow leaves the pit, if it leaves, and the freeboard required to maintain a hydrologic gradient towards the pit, may be important in understanding where backfill can be placed.

WRF seepage will contribute poor water, as discussed above, but backfill waste rock could contribute significantly to poor water quality if a water cover is not maintained over it.

Waste rock from the ACMA pit will go to the WRF, except PAG 7 material will be stockpiled and placed as backfill in the pit in Year 22. All waste rock from the Lewis pit will be backfilled into the ACMA pit. Backfill must be covered with a water cover if it contains PAG material. If the pit lake needs to be kept at, say 500 feet below the rim of the pit, instead of the currently planned 33 feet of freeboard, in order to maintain hydrologic containment, then potentially less Lewis or PAG 7 ACMA waste rock will be able to be placed in the pit.

This is a situation in which there is time to develop an adaptive management plan. Dewatering wells will provide the necessary hydrologic data during mining of the ACMA pit, in time to determine whether PAG 7 should be encapsulated in the WRF with the other PAG and/or whether Lewis pit waste rock needs to be stored on the surface.

I offer this not as an RFAI, but again as a point to illustrate how important it is to determine hydrologic containment at the pit. If a significant amount of waste rock cannot be backfilled into the pit, this will add quite a bit of expense at the latter end of mine life.

Rock conductivity and wetlands
If conductivity is higher than expected, more dewatering would need to occur. Is it possible that this could cause more wetlands to dry up than currently expected? If so, are there implications for mitigation?

Water treatment

Treatment during operations

The water treatment plant is designed for a maximum of 1,500 m^3/hr inflow. It is assumed that if rock conductivity, which drives the volume of pit dewatering water, is higher than anticipated, operators will "know fairly quickly" and be able to adapt the water treatment plant. However, this assumes that conductivity declines with depth. This underscores the importance of Sue Braumiller's comments on understanding the conductivity at depth before operations begin.

As noted in the meeting, the volume you can pump is one ceiling, the volume you can store is another.

- For impact analysis: In the event that high flow is encountered at depth, what does an extra 500 m^3/hr or 1,000 m^3/hr look like when added to the contact water pond or other storage areas? For how many days, weeks, months can this occur before there is no more storage, under high and low precipitation scenarios?

Per the water treatment plant design of using zeolites (synthetic greensand) as a key part of the process to remove arsenic and manganese,

- RFAI: Please provide case studies of mines that use the technology for these elements at similar scales. This is necessary to ensure that current technology is being applied.

Treatment post closure

My impression is that the Dry Stack Tailings Facility operating pond will have TDS high enough that it will be difficult for it to be treated at the water treatment plant, and instead will be stored until the end of mine life and drained into the pit. However, at some point when the pit lake overturns, there will also be high TDS. This suggests that pit lake overturn water could be difficult to treat.

- RFAI: Provide water quality for the DSTF operating pond, and apply that to a "water only" spill release scenario for Alternative 5A. This is necessary to compare Alternatives 2 and 5A.

- RFAI: Please explain what the difficulties are, what technology exists, and limitations for treating DSTF operating pond and pit lake water, such as the volume that can be treated and discharged and placement of waste that cannot be discharged.

Mercury

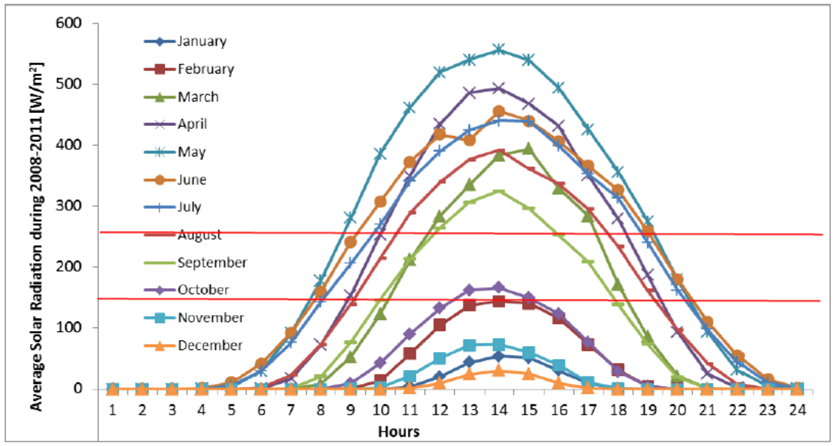
Assumptions on solar radiation

The majority of mercury in the gas phase will be released from the processing plant, but the second highest source will be the tailings facility, particularly in the later stages when the facility is large.

> *"….gaseous Hg emissions from four fugitive source categories at Donlin (Tailings Storage Facility (TSF), waste rock facility, ore stockpile and open pit) were estimated using methods similar to the Eckley studies but accounting for Donlin-specific data where feasible to account for* ***differences in solar radiation****, air temperature and geochemistry/Hg content between Donlin and the Nevada mines."* (Environ 2014c) (emphasis added)

Solar radiation on site is expected to be low 72% of the time, middle range 8% of the time, and high 20% of the time (Environ 2014c, Figure 3-5 and pgs 20-21) (bars added to separate low, medium, and high solar radiation levels).

Although the Donlin area receives a range of solar radiation, only "low" and "middle" radiation were used to calculate fugitive gas emissions.



Adapted from Fig. 3-5, DEIS. The figure shows the average solar radiation by month at the Donlin Camp site. The two red lines have been added to indicate the cut off for the designations of "low" and "middle" solar radiation. Data from above the second line was not included in equations for calculating fugitive mercury gas emissions from mine site facilities.

"We estimated beach Hg fluxes by applying the linear regressions equations developed for the ***low and middle solar regimes*** *to the Donlin solids Hg concentration as shown in Table 3-4. The equations developed are shown below, where f is the log(Hg flux) and c is log(Hg concentration)."* (Environ 2014c) (emphasis added)

Low Solar: $f = 0.604\,c + 3.238$ Mid Solar: $f = 0.542\,c + 4.36$

Table 3-4. Tailings beach mercury flux.

Beach Hg concentration (µg/g)	Log (Beach Hg concentration)	Log (Hg Flux in Low Solar Range)	Hg Flux in Low Solar Range (ng/m²-day)	Log (Hg Flux in Middle Solar Range)	Hg Flux in Middle Solar Range (ng/m²-day)
0.7	-0.15	3.14	1,396	4.28	18,902

* Values rounded off

Table 3-5. Monthly tailings beach Hg fluxes

Month	Daily Mean Solar Radiation at American Ridge (W/m²)	Solar Radiation Range	Tailings Beach Hg Flux (ng/m²-day)
January	8.9	Low	0
February	34.4	Low	0
March	111.8	Low	0
April	170.8	Medium	18,902
May	227.1	Medium	18,902
June	194.7	Medium	18,902
July	182.8	Medium	18,902
August	141.1	Medium	18,902
September	97.8	Low	1,396
October	41.1	Low	1,396
November	13.8	Low	0
December	4.3	Low	0

The difference between the fugitive gas emissions that could be released under low and high radiation for the tailings facility are striking (Environ 2014c, Table 3-4 above).

- RFAI: Adjust the fugitive gas emissions model to account for the percent of time with high solar radiation.

Potential for methylation
There remain a number of concerns about the degree to which mercury will impact the environment. I disagree that it is a "conservative assumption" to assume 100% of 1% of total mercury will methylate. Specifically

- Data does not support an assumption that the area will not support sulfate reducing bacteria (SRBs). The conclusion from the assumption is that only 1% of the total mercury will methylate.

- The Arcadis 2014 study did not appear to collect representative soil samples; there is a lack of samples from high sulfate areas (which would be more likely to support SRBs). This leads to potentially underestimating methylation rates.

- There is no consideration for how methylation rates could reasonably change in the future, due to exposure to fresh mercury particulates which methylate more easily than legacy cinnabar, or inputs that could stimulate SRB populations (additional sulfate release from the water treatment plant, lowered creek flow that could create anoxic and low flow areas, increased permafrost thaw that could provide fresh dissolved organic carbon).

If indeed more total mercury methylates, the impact analysis is inaccurate and further mitigations, such as reducing sulfate release from the wastewater treatment plant, may need to be discussed.

I would suggest collection of additional data that would provide better information for assessing impacts.

- ➢ RFAI: Please ensure soil and sediment samples utilized to determine mercury methylation are proportionally representative of the landscape to ensure there has not been any sampling bias. Soil should be collected from sites that are mineralized and unmineralized, high in sulfate and low in sulfate, high in organic material and low in organic material in proportions representative of the landscape. Sediment should be collected proportionally from areas of high and low oxygen (anoxic low flow/pool areas and higher flow oxygenated riffles, anoxic mucky bottoms and oxygenated gravel/cobble bottoms), as well as areas that are mineralized and unmineralized, high and low in sulfate, and high and low in organic material.

- ➢ RFAI: Perform laboratory tests with sediment, applying future wastewater effluent simulations under a range of temperatures and dissolved organic carbon concentrations. This will provide information on methylation potential. For example, mercury can be methylated by sulfate reducers, iron reducers, or methanogens all of which will be stimulated or repressed under different conditions.

- ➢ RFAI: Perform the same tests listed above with the simulated tailings that have been made for humidity cell and other tests. This will provide information on how dust consisting of tailings could act on the landscape.

RFAI: Determine the Hg(II) content of porewater in sediment. This can be done through sequential extraction or through a tin reduction method developed by USGS, Menlo Park. Brooks Rand Laboratories should be familiar with the process.