Final Peer Review Report

External Peer Review of EPA's Draft Document

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

September 17, 2012

Peer Reviewers:

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CONTENTS

EXECUTIVE SUMMARY

Versar, an independent EPA contractor, coordinated an external peer review of EPA's draft assessment, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* and organized and convened a three-day peer review meeting in Anchorage, Alaska on August 7-9, 2012. The peer review of EPA's draft assessment was initiated with a pre-meeting written peer review managed by Versar and conducted by 12 independent experts selected as peer reviewers. The role of the peer reviewers was to evaluate EPA's draft assessment and to provide a written review of the draft document (Volumes I-III) by responding to 14 Charge Questions put forth by EPA. Peer reviewers were charged only with evaluating the quality of the science included in EPA's draft assessment and were not charged with making any regulatory recommendations, commenting on any policy implications of EPA's role or mining development in the region, or reaching consensus in either their deliberations or written comments. The three-day peer review meeting, which directly followed the written peer review period, was organized as follows, with Days 1 and 2 being attended by approximately 220 members of the public:

- Day 1 of the meeting (Tuesday, August 7th) was dedicated to peer reviewers hearing oral comments from pre-registered public speakers. Approximately 95 members of the public shared oral comments with peer reviewers, related to assessment topics such as mining scenarios, effects on Alaska Native culture, effects on salmonid fish, and other areas.

- Day 2 of the meeting (Wednesday, August 8th), was dedicated to peer reviewer deliberations, which centered on individual responses to EPA's 14 Charge Questions.

- Day 3 (Thursday, August 9th) was a closed session to allow peer reviewers to document and summarize their major recommendations, after considering the public comments and deliberations of Days 1 and 2.

Day 3's documentation effort produced a Summary of Key Recommendations from Peer Reviewers, which is included in Section II of this report. Please note that neither the below summary list nor Section II of this report reflect a consensus or group perspective, but were compiled from a discussion of individual peer reviewer recommendations.

The reviewers commended EPA for an assessment of a challenging, complex scientific issue, working with data of variable quantity and quality. They offered numerous recommendations for improving the draft document, relating to scope, technical content, and clarity of presentation. While a more detailed description of the reviewers' recommendations is provided in Section II of this report, key recommendations for EPA's revisions to the document are highlighted below.

- The purpose and scope of the document should be clarified to correspond to the decisions that the assessment intends to support. This should include a statement of the intended audience(s) and range of decisions that the document could support, which would assist readers in understanding the approach, organization, level of detail, and uncertainties of the assessment.

- Accordingly, the document's organization should be consistent with ecological risk assessment guidance and build on the conceptual models presented in Section 3 that illustrate the framework for assessing potential effects of mine construction and operation on Bristol Bay watershed ecosystems.

- Clarify the geographic scope and coverage of the assessment (the entire Bristol Bay watershed or the Nushagak and Kvichak rivers' watersheds). Assess all rivers and streams that will be potentially influenced by the proposed mine (and its ancillary facilities, wastewater and solid waste management, and the transportation corridor), for they provide critical habitat for salmon production.

- The hypothetical mine scenario is the foundation for the assessment and reviewers recommend that EPA provide additional rationale for the scenarios assessed. Consider adopting a broader range of mine scenarios, especially smaller mine sizes, than the ones presented in the report.

- Incorporate mitigation measures (e.g., minimization, compensation, reclamation) from Appendix I into the document's mine scenarios discussion as they influence the range of mining impacts. Expand the discussion on the use of "best" management practices, because only "best" practice likely would be appropriate for a mine developed in the Bristol Bay watershed; anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself, without appropriate operational management controls, can always mitigate risk.

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, most likely will be necessary. Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity."

- Explain why the assessment's scope for wildlife and humans was limited to fish-mediated impacts. Reviewing effects beyond fish-mediated ones could improve the assessment because the potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts. Similarly, explain why fish-mediated effects on humans were limited to Alaska Native cultures.

- Strengthen the assessment with additional information to characterize the interconnectedness of groundwater and surface water and its importance to fish habitat in the watersheds. This discussion should consider seasonality (e.g., wet vs. dry summers or years) and how global climate change could influence hydrologic processes over the long term, which could pose challenges in distinguishing between impacts of climate change and mining impacts on the hydrology and salmonid ecosystem.

- The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community.

Further, primary and secondary production, including nutrient flux, was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other resident fishes, would provide additional context to this assessment of mine-related impacts.

- Explain how contaminants/metals of concern were selected. Include additional metals and their toxicities, as well as anticipated contaminant mixtures, in potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in this assessment.

- Provide consistent levels of detail for the different scenarios and stressors. For example, the document devotes 36 pages to catastrophic tailings storage facility failure, while sections on potential risks from pipeline, water treatment, and road/culvert failures are brief. The risks associated with potential spills from "day-to-day" operations deserve more attention in the assessment.

- Balance the level of detail between the text presented in the document and the useful information contained in the appendices. The appendices contain detailed and valuable information (roads, pipelines, mitigation, etc.) that should be summarized and incorporated in the document.

Following the meeting, peer reviewers were given additional time to complete their individual written reviews, which were submitted to Versar upon completion. These final written comments are contained in Section III of this report and fall into three categories: general impressions, responses to Charge Questions, and specific observations. Written peer review comments, as well as comments submitted to the docket by members of the public, will be considered by EPA as it works to revise the draft assessment document.

I. INTRODUCTION

I.1. Draft Assessment Background

In February 2011, EPA's National Center for Environmental Assessment (NCEA) announced a scientific assessment of Alaska's Bristol Bay watershed to understand and examine how future large-scale mining development projects may affect water quality, habitat, and salmon fisheries in the Bristol Bay watershed, which is home of one of the largest salmon populations in the world. On May 18, 2012, EPA released its draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. The assessment focuses primarily on the Nushagak and Kvichak river drainages, as they are the primary areas in the watershed open to large-scale development.

Following the release of the draft assessment, EPA held a public comment period, which allowed members of the public to submit comments on the assessment. More than 200,000 public comments were submitted to EPA's docket and a summary of these public comments was developed by EPA and is included in Appendix A.

I.2. Peer Review Process

Versar, an independent contractor, was tasked by EPA with assembling 12 experts to conduct an external peer review of EPA's draft assessment. The peer review process provides a documented, independent, and critical review of the draft assessment, and its purpose is to identify any problems, errors, or necessary improvements to the report prior to being published or otherwise released as a final document. In assembling these peer reviewers and coordinating the peer review, Versar was charged with evaluating the qualifications of peer review candidates, conducting a thorough conflict of interest (COI) screening process, independently selecting the 12 peer reviewers, distributing review materials, managing the written peer review period, organizing and hosting the public peer review meeting in Anchorage, Alaska, and developing a final peer review report.

The peer reviewer selection process was initiated with a public nomination period, during which members of the public were invited to nominate candidate reviewers with expertise in the following scientific fields relevant to sections of EPA's draft assessment: (1) metals mining; (2) salmon fisheries biology; (3) surface; subsurface, or watershed hydrology; (4) aquatic ecology; (5) biogeochemistry; (6) seismology; (7) ecotoxicology; (8) wildlife ecology; and (9) indigenous Alaskan cultures. In addition to publically-nominated candidates, Versar independently identified a number of candidates in relevant fields of expertise. In total, Versar evaluated approximately 100 candidate reviewers, including all publically-nominated candidates, as well as those identified through independent research. Versar's in-depth and multi-staged evaluation of qualifications was based on each candidate's biosketch, curriculum vitae (CV), and publications.

In addition to the evaluation of candidates' expertise, Versar conducted a thorough COI screening of candidate peer reviewers. Each candidate reviewer was required to complete a series of screening questions to help determine if they were involved with any work and/or organizations that might create a real or perceived COI. Following this initial screening process, the final 12 peer reviewers underwent two additional COI certifications ahead of and at the public peer review meeting.

Prior to narrowing down the pool of candidate reviewers, Versar carefully considered the results of the qualification and COI reviews and following approximately six weeks of candidate evaluations, Versar independently selected the final 12 experts and proposed them to EPA for consent. In addition, Versar selected Dr. Roy Stein as Chair of the peer review meeting due to his expertise in salmonid fisheries biology and aquatic ecology, as well as his strong record of chairing and participating in national scientific meetings and workshops. The full list of 12 peer reviewers who participated in this review is provided below; in addition, each reviewer's biographical sketch is included in Appendix B.

Following the selection process, Versar distributed EPA's full draft assessment (Volumes I-III) and 14 Charge Questions (see Section I.4) to the peer reviewers. The peer reviewers were charged with evaluating the quality of the science included in EPA's draft assessment by reviewing the draft assessment and responding to these Charge Questions. Peer reviewers were not charged with making any regulatory recommendations, commenting on any regulatory or policy implications of EPA's role or mining development in the region, or reaching consensus in either their written comments or public deliberations. Additionally, peer reviewers were provided with a summary of public comments and given access to public comments submitted during the draft document's public comment period ahead the public peer review meeting, but were not asked to evaluate or respond to documents submitted to the docket.

Versar managed the pre-meeting peer review period, which provided the peer reviewers approximately two months to evaluate the draft assessment (Volumes I-III) and complete their written reviews. Following the draft Charge Questions' public comment and revision period, peer reviewers received the final Charge Questions during the week of July 13th, 2012. Versar collected and compiled each peer reviewer's draft comments and distributed them to the peer reviewers and EPA to prepare for the public peer review meeting. These preliminary responses to the Charge Questions formed the basis of reviewer discussions on Day 2 of the public meeting.

Peer Reviewers:

David A. Atkins, M.S.
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WHPacific

Courtney Carothers, Ph.D.
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Washington State University

Gordon H. Reeves, Ph.D.
USDA Pacific Northwest Research Station

Charles Wesley Slaughter, Ph.D.
University of Idaho

John D. Stednick, Ph.D.
Colorado State University

Roy A. Stein, Ph.D. (Peer Review Chair)
The Ohio State University

William A. Stubblefield, Ph.D.
Oregon State University

Dirk van Zyl, Ph.D., P.E.
University of British Columbia

Phyllis K. Weber Scannell, Ph.D.
Scannell Scientific Services

Paul Whitney, Ph.D.
Independent Consultant

I.3. Peer Review Meeting

On August 7th, 8th, and 9th 2012, Versar convened a peer review meeting in Anchorage, Alaska. This meeting was held to conduct the scientific peer review of EPA's draft assessment and to provide members of the public with an opportunity to participate by either observing or providing oral comments to peer reviewers on Day 1 and observing peer reviewer deliberations on Day 2. The meeting followed both the assessment's public comment period, during which members of the public were able to submit written comments, and the pre-meeting written peer review period, during which the 12 selected peer reviewers read EPA's draft assessment and provided preliminary comments in response to Charge Questions.

Versar managed the pre-meeting registration period, which allowed members of the public to register to attend Days 1 and 2 as observers, as well as to make oral comments during Day 1's public comment session. Members of the public were able to register online, via Versar's registration website, as well as by telephone, email, or U.S. mail. Ahead of the meeting, Versar informed registered public speakers of their approximate speaking times and provided all registered attendees with pre-meeting handouts. On Days 1 and 2, approximately 220 members of the public attended the peer review meeting, with 95 of those attendees providing oral comments to the peer reviewers on Day 1. Please see Appendix C for the Agenda and Appendix D for a list of public attendees and speakers.

This three-day peer review meeting was organized as follows, with Days 1 and 2 being open to members of the public for observation:

- Day 1 of the meeting (Tuesday, August 7th) was dedicated to peer reviewers hearing oral comments from registered speakers. All speakers who pre-registered were provided the opportunity to share oral comments, which were limited to three minutes per speaker. The speaker schedule was set by Versar, and the order was determined by each registrant's self-selected comment category, which appeared on the online registration form. The order of comment categories at the meeting followed the order of their appearance on the online registration form (mine scenario & operational modes, potential failures and probabilities, hydrology, potential effects on Alaska Native culture, potential effects on fish, potential effects on wildlife; and other issues). Within each comment category, the order of speakers was determined by the date of registration, with those registering earliest speaking first. Speakers who were present but missed their speaking slot were provided time at the end of the speaking schedule to provide their comments. Approximately 95 members of the public shared oral comments with peer reviewers, related to assessment topics such as mining scenarios, effects on Native Alaskan culture, effects on salmonid fish, and other areas. Robert Wheeler of Triangle Associates served as the Day 1 Facilitator, managing the public comment session. Day 1 was webcast live to allow those who could not attend to observe.

- Day 2 of the meeting (Wednesday, August 8th), was dedicated to peer reviewer deliberations, which focused on responses to EPA's Charge Questions. Peer reviewers discussed all 14 Charge Questions, as well as their general impressions of the draft document, in front of an audience of public observers. Day 2 was also webcast live to allow those who could not attend to observe.

- Day 3 (Thursday, August 9th) was a closed session to allow peer reviewers to document and summarize their major recommendations, after considering the public comments and deliberations of Days 1 and 2. This session was not open to members of the public for observation or speaking; however, the results of this documentation are provided below, in Section II.

As noted above, Day 3 of the meeting was a closed session for the peer reviewers to document and summarize major recommendations from their deliberations on Day 2, which are presented in Section II of this report. EPA authors observed the session but did not engage in discussion with the peer reviewers or contribute to the development of the summary recommendations. In three instances, the reviewers requested clarification from EPA to assist in understanding the context in which the draft document was developed and under which it will be used. Specifically, following preliminary reviewer discussion about the lack of clarity in the draft document's purpose, scope, and intended audience, the Chair requested that EPA provide clarification. EPA shared that the assessment was initiated following requests from Federally-recognized tribes and intended to help the Agency better understand the potential impacts of large-scale mining in Bristol Bay, as well as to inform and outline the range of decision options for the Agency scientists and decision makers. EPA clarified that such decision options include, but are not limited to, any possible action under Clean Water Act Section 404(c). EPA further explained that the document was primarily developed to meet the Agency's need for scientific information, that the assessment itself is not decisional, and that it will not be the only source of information to inform future decision making.

Based on EPA's clarification, the reviewers resumed documentation efforts, which led to another inquiry later in the day on whether the draft document should be interpreted as a framework, decision-support document, or a risk assessment. In response to a request from reviewers for additional clarification, EPA explained that the draft document is neither a decision document, nor a framework; it is an assessment to evaluate the potential impacts of large-scale mining on salmon in the Bristol Bay watersheds and to inform future decision making options. It was also explained that, as a risk assessment, it uses conceptual models to help organize and present the analysis of sources, pathways, receptors, and endpoints.

Prior to the conclusion of Day 3's documentation efforts, reviewers inquired into the future use and intended audience of the draft document. The Chair requested additional elaboration from the EPA authors and EPA reiterated that the assessment will inform the development of and outline the Agency's future decision making options, while also educating and focusing stakeholders by characterizing various stressors and potential risks. Reviewers considered such clarifications and incorporated further questions or concerns into the recommendation summary effort (Section II), as well as their final individual comments.

Following the public peer review meeting, peer reviewers were given additional time to complete their individual written reviews. These final written comments are contained in Section III of this report. Written peer review comments, as well as comments submitted to the EPA docket by members of the public, will be considered by EPA as it revises the draft assessment document.

I.4. Charge Questions

Please provide narrative responses to each of the 14 Charge Questions below.

1) The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

2) A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

3) EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

4) Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?

5) Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?

6) Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?
7) Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

8) Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

9) Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

10) Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

11) Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

12) Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

13) Does the assessment identify and evaluate the uncertainties associated with the identified risks?

14) Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

II. SUMMARY OF KEY RECOMMENDATIONS FROM PEER REVIEWERS

This section includes a summary of the major recommendations put forth by the peer reviewers regarding EPA's draft assessment. In developing these recommendations, peer reviewers provided input on three major areas of the assessment – scope, technical content, and editorial suggestions. Reviewers also identified research needs for EPA to consider. Please note that this summary does not reflect a consensus or group perspective, but was compiled from a discussion of individual peer reviewer recommendations. Additional details, including references cited, can be found in the reviewers' individual comments in Section III.

Scope of the Document:

- Articulate the purpose of the document more clearly via a primer on the Ecological Risk Assessment process. If the purpose of the assessment is to inform EPA as the decision maker, then the level of detail should correspond to this purpose. The authors should justify and explain what level of detail is required.

- Include a statement upfront about the role of risk managers and other audiences, such as project managers/engineers, regulators, mine owners/operators. Knowing their role ensures inclusion of information necessary for any risk assessment by (1) describing the need for a risk assessment, (2) listing those decisions influenced, and (3) characterizing what risk managers require from the risk assessment.

- Explain why the scope for human and wildlife impacts was limited to fish-mediated effects, as well as why fish-mediated effects on humans were limited to Alaska Native cultures. Reviewing effects beyond fish-mediated ones (e.g., potential for complete loss of the subsistence way of life) would improve the assessment.

- Be more consistent throughout the document in terms of the level of detail provided for the different scenarios and stressors. For example, the document has devoted 36 pages to the discussion of catastrophic Tailings Storage Facility (TSF) failure, while sections on the pipeline, water treatment, and road/culvert failures are brief. Indeed, the long discussion on the TSF failure belies a certainty and understanding of dam failure dynamics that is inaccurate.

Technical Content:

<u>Mine Scenario</u>

- Consider the document to be a screening-level assessment of all potential stressors. Focusing on failure mode overemphasizes catastrophic events (e.g., TSF failing), rather than considering all potential stressors, such as holding mine owners strictly accountable for their day-to-day activities with regard to best practices.

- Reexamine the document's use of historical data and case studies to describe and estimate the risk of failure for certain mine facilities (including the TSF, pipeline, water treatment, etc.), as these examples from extant mines may not be an appropriate analog for a new mine in the Bristol Bay watershed.

- Expand the discussion on the use of "best" management practices, as the document states that the mine scenario employs "good," but not necessarily "best" practice. For a mine developed in the Bristol Bay watershed, only "best" practice likely would be appropriate and anything less may not be permitted. Even so, without a track record of "best" practice (e.g., new technologies), we cannot assume that technology, by itself without appropriate operational management controls, can always mitigate risk.

- Adopt a broader range of mine scenarios (not only minimum and maximum) so as to bound potential impacts, especially at smaller mine sizes (e.g., 50th percentile). Underground mine development, with its different impacts, also should be considered and included in the assessment.

- Based on the hypothetical mine scenario, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities, as well as perpetual water treatment and monitoring, will most likely be necessary (i.e., a "walk away" closure scenario after mining ends may not be possible). Therefore, emphasize how monitoring and management of the geotechnical integrity of waste rocks and tailing storage facilities should continue "In Perpetuity" (i.e., for at least tens of thousands of years). Discuss what conditions would need to be met to allow "walk away" closure in the Bristol Bay environment gaining insight into these observations from mines where perpetual treatment and monitoring are ongoing (e.g., the Equity Silver Mine in British Columbia).

- Identify, in technical detail, how exploratory effects (e.g., drill holes, blasting, overflight, etc.) were managed. This includes roads, airstrips, helipads, camps, fuel dumps, and ATV trails that have already been developed or imposed on the watershed, and what "mitigation" already has been undertaken on those sites. Assess the consequences/impacts of these activities in the Cumulative Risks section.

<u>Risks to Salmonid Fish</u>

- Place potential mining impacts in the context of the entire Bristol Bay watershed by emphasizing the relative magnitude of impacts. For example, of the total salmon habitat, assess the proportion lost due to mining. Further, reflect on the non-linear nature of the relationship between habitat and salmon production; 5% of the habitat could be critical and thus responsible for 20% or more of salmon recruitment. Intrinsic potential, which measures the ability of particular habitats to support fishes, would lend credibility to this analysis.

- Include a section on the impact of Global Climate Change with explicit reference to a monitoring program that will allow scientists, if the mine is built, to distinguish between effects of climate change and mining effects on the physical and biological components of this ecosystem.

- Explicitly recognize that the transportation corridor and all associated ancillary development, including future resource developments made possible by the initial mining project, will necessarily and inevitably have impacts (hydrologic, noise, dust, emissions, etc.). These impacts will vary in duration, intensity, severity, relative importance, spatial dispersion, and inevitably expand geographically through time with further "development." These impacts should be incorporated into the Cumulative Risks section.

- Incorporate current research findings into stream crossing and culvert-design practices (e.g., arch culverts, bridges, etc.).

- Recognize in the assessment that risk and impact are not equivalent. Risk may be low, but the potential impact could be huge (e.g., in the case of a TSF failure).

- Recognize and justify chronic behavioral endpoints, such as those potentially affecting survival and long-term success of fish populations.

Wildlife

- Recognize that the draft assessment did not account for all levels of ecology, such as the individual (e.g., a bald eagle nest), population, community, ecosystem, and landscape levels. Fold other levels of organization into the stressors assessment where appropriate or justify a more limited approach.

- Discuss in the document fishes other than salmonids The assessment focuses on risks to sockeye salmon in the Bristol Bay watershed (and also considers anadromous salmonids, rainbow trout, and Dolly Varden), but does not account for potential impacts to other members of the resident fish community. Further, primary and secondary production, including nutrient flux was not addressed. Expanding the assessment to consider other levels of organization, including direct as well as indirect effects on wildlife and other fish, would provide additional context in the assessment of mine-related impacts.

Human Cultures

- Use case histories to provide insight and anticipate mining impacts on Alaska Natives (e.g., those exemplifying the Exxon Valdez oil spill impacts, cumulative effects of oil and gas development in the North Slope region, and social impacts related to mining development in Alaska).

- As noted above (Scope of the Document), clarify why the scope was limited to fish-mediated effects. The potential direct and indirect impacts for human cultures extend far beyond fish-mediated impacts (e.g., potential complete loss of the subsistence way of life). The rationale for this narrow focus should be fully explained. In addition, a clear explanation should be given for why fish-mediated human impacts focused only on Alaska Native cultures.

Water Balance/Hydrology

- Better characterize water resources and assess the potential effect of mine development on these resources by (1) generating a diagram similar to the conceptual models beginning on page 3-7 to illustrate the potential effects of mine construction and operation on surface- and ground-water hydrology; (2) developing a quantitative water balance and identifying water gains and losses; (3) identifying seasonality of hydrologic processes, including frozen soils and their associated values (e.g., mm/yr) for each component of the water balance; (4) incorporating these processes into a landscape characterization; (5) evaluating how global climate change will influence these hydrologic processes and rates; and 6) using this characterization to demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development.

- Demonstrate the interconnectedness of groundwater, surface water, hyporheic zone, and its importance to fish habitat. Address how interconnectedness changes over time – seasonally, and with varying weather (e.g., wet vs. dry summers or years, and over the long term as climate changes).

- Provide information on all rivers, including ephemeral and intermittent streams, and first-order to main-stem streams that could be potentially influenced by the proposed mine, its ancillary facilities, and the transportation corridor.

- Emphasize the importance of a thorough characterization of the leaching potential of acid-generating and non-acid generating waste rock and tailings, given the low buffering capacity and mineral content in the streams and wetlands that could receive runoff and treated water from the proposed mine. Recognize that collection and treatment of runoff and leachate generated will be critical to maintain baseline water chemistry in these streams and wetlands.

<u>Geochemistry/Metals</u>

- Reference the most current geochemistry data on potentially acid-generating, non-acid generating, and metal leaching so as to describe any potential effects of seepage and changes to surface- and ground-water quality via non-catastrophic failure.

- Explain how contaminants/metals were selected (and others ignored) by EPA as causes for concern. Information should be included on additional metals and their toxicity so as to assess impacts of potential leachates. The Pebble Limited Partnership baseline document presented additional metals that might be useful to include in the assessment.

<u>Mitigation Measures</u>

- Incorporate the critical mitigation information from Appendix I into the main report's mine scenarios. Include standard mitigation measures that could provide insight into how well they might work in this context. If this information is not included in the main report, then justify its absence.

- Emphasize mitigation measures (e.g., minimization, compensation, reclamation) in the main report, as they ultimately influence the range of mining impacts and consider time frames of mitigation or reclamation measures (e.g., immediate response, long-term reclamation).

<u>Uncertainties and Limitations</u>

- Clarify the uncertainty vs. certainty in Chapter 8 by (1) defining levels of uncertainty and (2) assessing the certainty of some mine impacts. Discuss data limitations in the context of uncertainty.

- Articulate early in the document how much uncertainty is acceptable. The assessment provides little insight with respect to the decisions the document is intended to support.

Editorial Suggestions:

- The title of the document leads one to believe that the assessment addresses the entire Bristol Bay watershed; rather, the report deals with two major rivers and their watersheds, the Nushagak and Kvichak. Thus, the title should be changed to reflect the emphasis on these two rivers and their watersheds. A possible title may be "An Examination (or identification) of the Potential Impacts of Mining and Mining Associated Activities on Salmon Ecosystems in the Nushagak River and Kvichak River watersheds, Bristol Bay."

- Revise the Executive Summary to more precisely reflect the findings in the document.

- The appendices contain detailed and useful information that should be summarized and included in the main document (e.g., Appendix E: Economics, Appendix G: Road and Pipelines, and Appendix I: Mitigation). Additionally, consider expanding the preface to include information on the use of the appendices. If the information is not included in the main report, then justify its absence.

- Discuss in more detail the instructive and well-thought-out conceptual models (pages 3-7 to 3-11) illustrating the impacts of mining on Bristol Bay ecosystem processes. Also, consider expanding the conceptual models to include wildlife, fish-wildlife interactions, vegetation/terrestrial habitat, and hydrologic processes. Allow them to guide the text because they appear detailed and complete.

- Incorporate the information contained in the conceptual models into a formal framework, such as a Bayesian or other decision-analysis models.

- Generate a standard operating protocol for significant figures and use it throughout the document.

- Remove all references to Mount St. Helens as a surrogate for a TSF failure. Using a non-human-caused release of material into the ecosystem as an analogue for a mine failure is not comparable in terms of likelihood or risk for a human-caused release. It would be more appropriate to extrapolate from the impacts of known mine failures.

- Ensure that the draft assessment remains part of the public record, allowing the document history to remain intact.

Research Needs:

- What are the acute and chronic impacts of mixtures of contaminants, including metals, acid mine drainage, etc., on the fauna and flora of the Nushagak River and Kvichak River watersheds? What species are most sensitive and might surrogate species exist for those for which we do not have data? Review the European literature and regulatory requirements for additional data.

- Can an inventory of nutrients, total organic carbon, and dissolved organic carbon inputs to aquatic environments be developed that demonstrates their relative magnitude and spatial variation from headwaters to Bristol Bay? What is the relative importance of marine-derived nutrients relative to other nutrients from watershed and terrestrial sources? What is the current atmospheric input of nutrients?

- What are the locations of subsistence areas and can these areas be characterized and differentiated by collecting local environmental and ecological knowledge (e.g., fish overwintering areas, climate change, ecological shifts, etc.)?

- What impact might mining have on other important wildlife species in the basin (e.g., freshwater seals in Iliamna Lake)?

- What is the comprehensive hydrologic regime of the specific project mining area, and the broader watershed system as characterized by baseline monitoring, spatial distribution, and quantitative flow of surface- and ground-waters?

- What is the cumulative impact of commercial fisheries on the Bristol Bay watershed, especially in an ecosystem context as related to marine-derived nutrient and energy flow? Acknowledge that commercial fishing has had an impact on the amount of marine-derived nutrients returned to the watersheds.

III. WRITTEN PEER REVIEW COMMENTS

III.1. General Impressions

David A. Atkins, M.S.

The Bristol Bay Watershed Assessment (the Assessment) presents a comprehensive overview of current conditions in the watershed and establishes the uniqueness and global importance of the area to global salmon ecology (e.g., the report states that nearly 50% of the global sockeye salmon population comes from Bristol Bay and nearly 50% of the salmon in Bristol Bay come from the Nushagak and Kvichak Rivers, which encompass nearly half of the watershed area). The report also describes in detail the importance of the fishery to Native Alaska cultures, the importance and uniqueness of subsistence activities, and the scale of the commercial fishery. Furthermore, the report also outlines the reliance of the local economy on the salmon fishery.

There is no question that a mine, especially of the type and magnitude analyzed in the Assessment, could have significant impacts and that if these impacts are not or cannot be properly managed and/or mitigated, the consequences could be profound. The Assessment presents a mining scenario based on preliminary documents prepared for the Pebble Project, which sets out a conventional approach for development of a very large mine that includes open-pit and block-cave underground mining methods and conventional waste rock and tailings management. Development of the mine as proposed would eliminate streams and wetlands in the project area permanently. The importance of this impact is not put in context of the watershed as a whole, so it is not possible to determine the magnitude of the risk to salmon. The Assessment also did not consider whether there are any methods that could effectively minimize, mitigate or compensate for these impacts.

The Assessment also focuses on the risk of failure of the tailings storage facility, a low probability, but high impact scenario. The Assessment further describes the potential for long-term acid and metals production from waste rock and the necessity for water treatment. Under the mining scenario as described, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities and perpetual water treatment could be necessary. In addition, failure is always a possibility, albeit a possibility that is difficult to quantify with any degree of certainty as explained in the Assessment. The Assessment also does not consider alternative engineering strategies (so called 'best practice' approaches) that could lessen the risk of failure and possibly the necessity for perpetual management and water treatment. As such, the report could be considered a screening level assessment that presents the likelihood of occurrence and corresponding consequences of failures under the presented development scenario, but does not describe the magnitude of risk to salmon.

Steve Buckley, M.S., CPG

The assessment attempts to evaluate the potential impacts of mining development in the Nushagak and Kvichak watersheds. The main deficiency in the assessment is that it uses only two hypothetical mine scenarios to bracket the potential impacts of mining activities on the ecological resources in the watershed. Both of these mine scenarios are larger than the 90th percentile of all porphyry copper deposits in the world. In order to properly assess the potential effects of mining activities, in the absence of any specific mining proposal, a minimum mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits would be more appropriate. Three or four mine scenarios would allow for a broad range of analysis, and the reader would be able to put the potential impacts of mining development in wider perspective.

A large part of the assessment provides information related to catastrophic potential system failures such as tailings dam failures and pipeline ruptures. There is inadequate information on, and analysis of, potential mitigation measures at the early stages of mine development, which would attempt to reduce the impacts of mining activities on fish and water quality. The bulk of the document is dedicated to evaluating the impacts of tailings dam failure on aquatic resources and yet in Chapter 4, the assessment provides a probability of tailings dam failure at 1 in every 2,000 mine years.

The assessment identifies the interconnectivity of groundwater, surface water, and fish habitat as being a major component of the quality of the fishery in the watershed yet puts relatively little effort into the analysis of the detailed relationships between groundwater, surface water, water quality, and fish habitat, even though this is likely the most important factor in assessing the potential impacts of mining activities on the fisheries in the watershed.

Additional mine scenarios and a more detailed investigation of the geomorphology, surface, and groundwater hydrology and their relation to fish habitat would provide the reader with a more accurate and more useful scope of analysis.

Courtney Carothers, Ph.D.

Synopsis: EPA's draft document examines the potential impacts of large-scale mining development on the quality, quantity, and genetic diversity of salmonid fish species in the Nushagak River and Kvichak River watersheds of Bristol Bay, Alaska. To the extent that both wildlife and Alaska Native communities in the region depend upon salmonids, fish-mediated impacts to these other "endpoints of interest" are also explored. A hypothetical mining scenario, informed by current exploration, planning, and study in the Pebble deposit area, is described using minimum and maximum estimates for mine production and includes the construction of a transportation corridor to Cook Inlet. Even in the absence of any failures or accidents, construction and operation of such a mine would have significant impacts to salmonids in stream systems proximate to the mine footprint with some related impacts to wildlife and human communities. At least one or more accidents or failures are expected to occur over the long lifetime of the mine. Immediate and long-term severe impacts to salmonids are expected to occur with any significant failure, with relatedly pronounced impacts to wildlife and Alaska Native communities in the region. Multiple mines in the region would amplify these impacts.

General impressions: Overall, the main report is well-written and presents information in multiple ways, including: narrative, conceptual models, images, figures, and tables. The report synthesizes a large amount of information, much of which is described in detail in the report's appendices. The report highlights the unique characteristics of this watershed: incredibly productive and sustainable salmon fisheries, relatively little large-scale modification of the natural environment, and active subsistence-based indigenous cultures still occupying their homelands and many still using their Native language. Making central these features of the watershed, the tone of the report suggests that some negative impacts to salmonids, wildlife, and Alaska Native cultures are necessarily expected to accompany any large-scale mining development and operation in this region.

The document should provide a clear articulation of the scope of human impacts considered in this assessment. The main report considers only *fish-mediated* impacts to *Alaska Native cultures*. The restriction of scope to only fish-mediated impacts should be further clarified. A host of social, cultural, and economic impacts would accompany large-scale mining development in this region. These direct and indirect human impacts, both positive and negative, were the focus of many public comments on the EPA draft document, yet they fall outside of the scope of consideration in this report. If the narrowed scope of fish-mediated impacts is justified, these other impacts should be clearly identified as outside of the scope of this report. At times in the report (e.g., p. 5-77), these other impacts are superficially mentioned. Unless a full treatment of these impacts is included (including a presentation of a large literature explores these impacts internationally, e.g., Ballard and Banks 2003), this cursory discussion should be removed. If maintained, the narrow scope should be reiterated throughout the report to remind the reader that these larger human impacts are not considered.

The report should articulate more clearly why Alaska Native cultures are the only human groups included in the assessment of fish-mediated human impacts. The report notes: "because…Alaska Native cultures are intimately connected and dependent upon fish, …the culture and human welfare of indigenous peoples, as affected by changes in the fisheries are additional endpoints of the assessment" (ES-1-2). This suggests that the limitation of fish-mediated human considerations to Alaska Native cultures is not due to government-to-government relationship between tribes and the federal government, nor the special status afforded by environmental justice concerns, but rather because of their close connections to, and dependence on fish. Arguably, other human groups also have connections to fish and depend upon on salmon in this region in various ways, but are excluded from analysis of potential impact in this report. This comment is not meant to detract from the importance of the focus on Alaska Native cultures and the primarily indigenous communities in this region for assessing fish-related impacts. Rather, the comment is made to suggest the inclusion of a clear justification for this focus, or the broadening of scope to include other human groups who are also connected to, and dependent upon, salmon in this region (e.g., substantial information on the economic dimensions of salmon resources in this region is summarized in Appendix E, but little is presented in the main report). Additionally, the assessment of fish-mediated effects to Alaska Native cultures is primarily focused on subsistence fisheries. More discussion of the role of commercial engagements in salmon fisheries (e.g., commercial harvesting, processing, recreational fishing businesses and employment) in the watershed communities in this region would be helpful.

Dennis D. Dauble, Ph.D.

Overall, the main report and each of the accompanying appendices were well written. I was unable to identify major inaccuracies or bias in the material as presented. There were shortcomings in the main report, however. For example, some topics would benefit by being expanded (Sections 5.6 and 8.7), while others have more detail than appeared necessary (Section 6.1). The assessment effectively addressed three appropriate time periods: (1) operation, (2) post-closure, and (3) perpetuity. Potential effects are bounded by a minimum and maximum mine size, which is also appropriate. Inclusion of inference by analogy strengthened the conclusions reached in the assessment and helped validate results obtained from model predictions.

Most figures and tables were useful. The conceptual models and accompanying illustrations of potential habitat effects (Figs 3-2A and C) are important because they provide a view of complicated pathways and relationships among potential activities and environmental attributes.

However, these relationships are not revisited in any detail later in the document. I recommend discussing the conceptual models in more detail in the main report (Section 3.6) and summary section in Chapter 8.

The Integrated Risk Assessment (Chapter 8) did a creditable job of summarizing habitat losses and risks from mine operations. What is missing, however, are quantitative descriptions of habitat lost relative to total habitat available in the larger watershed and individual systems. Habitat loss should be further discussed in terms of salmonid life stage and productivity (i.e., not all stream miles are equal).

If anything, the conclusions could be strengthened. The summary of uncertainties and limitations (Section 8.5) dwells on things that "could not be quantified" due to lack of information, model limitations, or insufficient resources. Thus, this reader was left somewhat in limbo as to the potential magnitude of effects from mining activities. (Note that this "neutral voice" is carried throughout the Executive Summary). Many people might interpret such statements of uncertainty as no proven effect. My point is that probable environmental consequences of mining activities are much greater than this report alludes to, given that consequences are likely, even if their magnitude is "uncertain."

Section 8.7 is perhaps the most important section of the report. It should be comprehensive, i.e., cover all resources and be more quantitative. Missing from the summary were impacts on wildlife, human culture, resident fish, and other ecological resources. Essential details from Appendices A, C, E, F, and I, for example, could be synthesized and moved into the main report.

Gordon H. Reeves, Ph.D.

The purpose of the report is unclear, which makes it difficult to assess. The report focused on the potential impact of a hypothetical mine on salmon and salmon habitat in two watersheds in Bristol Bay, AK. However, it is not clear whether the analysis was intended to be a case study of the potential impacts of a hypothetical mine under the various scenarios presented or whether the intent was to develop a framework for assessing mining scenarios. These are two very different objectives, which makes it critical that the purpose be clearly stated in the beginning of the document so that reviewers and others understand the purpose of the document. There certainly was much confusion among members of the review panel and the people who commented on the report because of this.

I think that the credibility of the report could be improved substantially if the analyses were formalized and more clearly articulated and defined. The authors could consider using a decision support process, such as a Bayesian approach (see Marcot, B.G., J.D. Steventon, G.D. Sutherland, and R.K. McCann. 2006. Guidelines for developing and updating Bayesian belief networks applied to ecological modeling and conservation. Canadian Journal of Forest Research 36: 3063-3074). This would provide more transparency to any analysis and allow others to better understand how results and conclusions were derived. Also, it would identify critical relations that should be considered and provide insight about the consequences of not considering them. This will undoubtedly take additional time and effort, but I believe it would be well worthwhile. Examples of where such analysis has been done are in: (1) Armstrup et al. 2008. A Bayesian Network Modeling Approach to Forecasting the 21st Century Worldwide Status of Polar Bears. Pages 213-268. *in* E.T. DeWeaver et al., editors. Artic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications. Geophysical Monograph 180. American Geophysical Union, Washington, D.C.; and (2) Lee, D.C. et al. 1997. Broadscale

Assessment of Aquatic Species and Habitats. Vol. III, Chapter 4. U.S. Forest Service, General Technical Report PNW-GTR-405. Portland, Oregon.

I thought one of the strongest aspects of the report were the conceptual diagrams of relations between the various aspects of the development and operation of a mine and the components of the ecosystem that influence salmon and their habitat (Chapter 3). These diagrams show the components of the ecosystem, the relation among them, and how mine impacts could potentially influence given parts of the ecosystem directly or indirectly as a result of cascading effects. They are a good first step in developing a decision support framework, as suggested in the previous paragraph. There was, however, little discussion about them in the text and it was not clear if or how they were used or considered in the analyses. The authors should, at the very least, clearly identify which parts of the networks were considered and why these particular avenues were pursued and others were not. This would provide additional insights into potential limitations of the analyses and results.

If this was a case study, the report appeared to have considered available literature and reports on all aspects of the mine, its operation and the parameters that could be affected by it. I am not familiar with this literature so it is not possible for me to comment on the adequacy of the literature and reports considered. Assumptions about the location and operation of the mine seemed reasonable and the authors clearly articulated limitations of available data and other information concerning the mine's location and operation. I found the consideration of the mine during the various phases of development and operation and the discussion about potential development of other mines in the area particularly insightful. Inclusion of experiences from other mining operations was also helpful in understanding the conclusions about potential impacts of the mine and its operation over time. Additionally, the consideration of the potential development of other mines in the area was particularly insightful and provided a good picture, albeit not in depth, of potential cumulative effects on aquatic resources in the Bristol Bay area.

Parts of the report on the ecology of fish and aquatic ecosystems, road, and culverts – topics that I am familiar with – were covered very well and the conclusions about potential impacts of the mine and its operation generally seemed justified. The authors presented available data and information on fish distribution and abundance relative to the presumed location of the various components of the mine operation. Their analyses were appropriate but rather cursory, which is not unexpected given the restrictions of time and available data. However, there are some additional considerations and analyses that could be done, which I think would improve the report. I identify these in answers to specific charge questions. Limitations of the results were readily acknowledged. However, as mentioned above, there are additional limitations that resulted from only considering selected potential avenues of impacts. These should be discussed in the revision.

The authors do a good job of summarizing the scientific literature on salmon ecosystems, roads, and culverts. Most of this is from studies in areas outside of Bristol Bay. Interpretations of the findings were accurate. However, there was no discussion about potential limitations on the application of the studies to the area being considered. For example, Furniss et al. (1991) deals with roads in forest and rangeland settings. These are very different environments than Bristol Bay, which suggests that road impacts will likely differ. Much attention is given to "headwater streams" and their ecological importance (p. 5-19 – 5-21). Headwater streams for the area of consideration need to be defined so that appropriateness of the application of the literature can be better judged.

A major component that is missing from the report is consideration of the potential impacts of climate change. Climate change is identified as a factor in the conceptual model of potential habitat and water quality effects associated with mine accidents and catastrophic failures (Fig. 3-2D). However, I believe that it is a key factor that will have influence in all aspects of the assessment, not just failures and natural disturbance events (Fig. 3-2C). It needs to be considered in other aspects, such as water quality and availability. Climate change should also be included in any analysis because it will be critical to build it into any monitoring program that is developed in order to be able to differentiate its impact on salmon and their habitat from potential impacts of the mine.

Charles Wesley Slaughter, Ph.D.

Provision of full-color versions of all figures would have been helpful to the reviewers.

The Assessment (Volume 1 – Main Report) provides a fairly comprehensive review of fisheries-driven issues, from the perspective of salmonids. Appendices (Volumes 2 and 3) are very informative. The high significance of the Bristol Bay watershed, specifically of the Nushagak and Kvichak river systems, for commercial fisheries on the global scale and for sport and subsistence fisheries at the regional and local scales, was appropriately described.

The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with less attention on "salmon-mediated" impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

Chapter 2 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region.

The "Water Management" section (4.3.7) seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…" do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.

Perhaps I missed it, but I found no acknowledgment of the potential presence of or consequences of perennially frozen soils – permafrost – in the Bristol Bay watershed, or more specifically in the Pebble ore deposit locale or the proposed transportation corridor. Selkregg (1976), Fig. 136, shows soils of the Pebble locale as INT/2g, INT/1g – HYP, or SOU/2g-HYP – that is, well-drained gravelly soils (INT) or well-drained acidic soils (SOU) with interspersed peaty, poorly-drained shallow discontinuous permafrost. There is abundant literature on the influence of permafrost on engineered structures, roads, hydrology, etc. Even if the bulk of the terrain involved in the proposed Pebble mine, road and infrastructure project is founded on well-drained gravelly soils, any interspersed permafrost-underlain terrain can prove problematic in terms of landscape stability, potential erosion, and consequent structural, engineering, hydrologic and water quality issues. See Specific Observations for a few suggested references in**.**

While there is extensive discussion of a proposed transportation corridor, there was no mention of construction of a major airfield. A project of this magnitude would undoubtedly require development of a facility in close proximity to the mine(s) capable of handling C130 and commercial jet passenger and cargo traffic, at least to the 737 class, if not 747. I don't know what the footprint for such an airfield would be, but it would be substantial, and with requisite roads, fuel handling, etc., would be a major project in itself. This would seem to be a logical component of a comprehensive assessment of the potential Pebble project.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects. This Assessment is thus inadequate in terms of considering potential broader consequences for the Bristol Bay watershed system.

John D. Stednick, Ph.D.

The purpose of the document is not clearly stated in either the Executive Summary or the Introduction. Need to specifically identify the document as an environmental risk assessment. There is a misconception that it is a CWA Section 404(c) review, rather than an environmental risk assessment. The document should have the utility to inform future users of the risk to the watershed resources from mining activities in the watershed. The assessment can be used by others for decision making purposes, and includes current and appropriate methodologies for all identified stressors, such that study results can be duplicated. And all stressors are evaluated to a similar level of detail.

The document characterizes the potential environmental effects of an open pit mine over a copper porphyry complex in southwest Alaska using a hypothetical mine design based on similar ore deposits and mine complexes elsewhere. Proposed mine activity has been identified by the Pebble Limited Partnership though Northern Minerals Dynasty and should be cited to improve applicability of the risk assessment. Furthermore, a wider range of mining scenarios should be developed and analyzed for environmental risk assessment. Environmental consequences were estimated by the environmental risk assessment model approach for both 'no-failure' and 'failure' scenarios. The Executive Summary concluded that the effects of mine development resulted in significant salmon habitat losses. Potential effects on other aquatic species were not identified. The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures. Nor did the assessment look at the full range of mine development scenarios, specifically what are the risks associated with a smaller underground operation?

The conclusions of the Executive Summary are strongly worded (e.g., pages ES 13 to 24), yet the uncertainties presented later in the report make the strong conclusions tenuous. An expanded discussion of uncertainties and limitations may temper those 'conclusions.'

Site characterization/description of current conditions is too brief. More information is needed for a full site characterization. Any reader unfamiliar with the setting would not fully understand the physical, biological, or ecological inventories and linkages in the study area. The risk assessment of failure and no failure are covered in Chapters 5 and 6 with varying levels of detail and substantiation of conclusions. Statements like "salmon is important in the human diet, thus a salmon loss affects human health" seem like a weak argument, especially when additional information in the appendix suggests a larger effect.

The Pebble Limited Partnership has a large environmental baseline database (EBD), but does not appear to be cited or used. Justification for the inclusion or exclusion of these data should be made. Reference is often made to various data, but these data were not presented.

Review and revise the water balance section, which would include: 1) generating a diagram or conceptual figure similar to page 3-7 to illustrate the potential effects of mine construction and operation on surface and groundwater hydrology; 2) developing a quantitative water balance for surface and groundwater resources; 3) incorporating seasonality (especially assessing the role of frozen soil); 4) identifying hydrologic processes and their associated values (e.g., mm/yr) for each component of the water balance in time and space, and then incorporating into a landscape characterization; 5) demonstrating the interconnectedness of groundwater, surface water, and the importance to fish habitat and stream productivity; 6) evaluating the influence of global climate change on these hydrologic processes and rates; and 7) using this characterization demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development and closure scenarios.

One common theme that emerged from the public comment session during the peer review meeting in Anchorage, AK was the questioning of the document timing, from draft release to the public comment period to the unannounced completion of a final document. These concerns should be addressed in the new document.

Roy A. Stein, Ph.D.

Accuracy of Presentation. Overall, I was pleased with the accuracy of the presentation. Typically, peer-reviewed citations to the scientific literature were cited as supportive documentation for most all of the factual information (though the well-developed appendices, e.g., Appendix E: Economics; Appendix I: Mitigation, could be used to far better advantage, see below). Unfortunately, in the main report, many data are missing, especially with regard to salmonid populations, their diversity (both across species wand within species across populations), their relative population sizes, their distribution across the watershed, their vital rates (i.e., recruitment, growth, and survival across life stages), and to what extent the Pebble Mine and its associated activities will reduce these populations (for there is no question they will indeed be reduced through both the mine footprint and all allied operations in the drainage), both through impacts on individual populations and the overall production of salmonids (and other fishes) in the Bristol Bay watershed. Whereas I am relatively confident about accuracy of the fisheries information included, I cannot comment in detail regarding the accuracy of the mining information or impacts on the Native Alaskan cultures (though the impact of the mine on this culture was confined to fish-mediated effects). That a Native Alaskan culture 4,000 years old is in jeopardy bothers me greatly; might this complete subsistence way of life in the Bristol Bay watershed be eliminated with the exploitation of the copper via open-pit mining? In turn, what impacts might there be on subsistence users, other than Native Alaskans? Even though these sections seemed reasonably well presented (with caveats above) and appropriately supported with citations, they do lie beyond my expertise.

My concerns about the document revolve around issues that were not considered, i.e., Global Climate Change, "In Perpetuity" issues, groundwater-surface water exchange issues (owing to missing information), impacts of Routine Mine Operations in a more realistic setting, the seemingly undue influence on a failure of the Tailings Storage Facility, and other somewhat more minor issues (see comments below). With any revision, the authors should include this information by eliminating redundancy (see below), thereby not increasing document length.

Clarity of Presentation. Generally speaking, I believe that the writing was intelligent, reasonably insightful, and, more specifically, on task. One significant criticism with regard to the presentation revolves around the organization of the document. As detailed below, the organizational scheme lent itself to redundancy, from the Introduction through the various chapters to the Integrated Risks Characterization chapter. Owing to this redundancy, the report is likely too long by about 20% and any revision and shortening should serve to improve its impact on readers.

The conceptual block and arrow diagrams (pages 3-7 to 3-11) were quite instructive. They nicely demonstrate the interactions that occur within this mining scenario. The main report would be much improved if text were to review this set of interactions. Clearly, a tremendous amount of time, effort, and thought went into generating these diagrams and it is indeed a true shortcoming of the main report that essentially no text was spent stepping through these diagrams.

Soundness of Conclusions. The conclusions were well supported, where there were published data to support them. Many statements that could be interpreted as conclusions were often more qualitative than desirable in a review document such as this one, owing to the lack of information (percent of salmonids lost owing to routine mine operations, impacts of mining and the transportation corridor on wetlands, extent of groundwater-surface water disruptions, just to name a few). Consequently, the soundness of the conclusions are somewhat compromised by a lack of information.

In addition, what would aid readers is a succinct statement of the purpose (risk assessment?, impact on water quality and then through to fishes and beyond?, etc.) and scope (relatively narrow impact of the mine on salmonids and ripple effects out from there) of the document early in the initial chapter. In so doing, both reviewers and readers will be informed as to the direction of the document and thus better informed as they move through the document.

Finally, a portion of the public testimony complained about the process, specifically about the time allowed for document review, the data reviewed, the validity of the hypothetical mine, etc. Though I found most all comments to be somewhat disingenuous, I still would offer the following advice: Provide a section upfront that deals with process issues surrounding the review, i.e., explaining the constraints under which EPA was operating; without a section like this, complaints, such as those described above (coming from just one segment of the public), will go unanswered.

William A. Stubblefield, Ph.D.

The document, "An Assessment Of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," is a well-written, comprehensive document that employs a risk assessment-type approach to an *a priori* evaluation of potential environmental effects on the ecosystem and potential receptor species (e.g., salmon) that may be affected by a potential copper mine located in the Bristol Bay area of Alaska. This document is somewhat unique, in that no actual mine has been proposed at the location and few site- or project-specific data are available. Therefore, no specific information about development plans and potential operational and closure activities associated with the mine are available. Rather, the authors have attempted to develop a hypothetical mine and attempted to assess possible environmental effects associated with mine development, operation, and closure. Although interesting, the potential reality of the assessment is somewhat questionable. It is also unclear why EPA undertook this evaluation, given that a more realistic assessment could probably have been conducted once an actual mine was proposed and greater detail about operational parameters available. The approach taken in the document attempted to be comprehensive and evaluated a variety of scenarios that may affect aquatic resources in the Bristol Bay region. Given the importance of salmon populations in the area, both from a financial and societal perspective, it is important that a comprehensive evaluation of potential environmental effects associated with mine development and operations be conducted. The authors have attempted to conduct such a comprehensive evaluation and have attempted to quantify (to the extent possible) the probability of adverse effects occurring. Implementation of this approach is proper, and with the correct data, can provide a comprehensive evaluation of potential environmental effects. Unfortunately, because of the hypothetical nature of the approach employed, the uncertainty associated with the assessment, and therefore the utility of the assessment, is questionable.

A variety of uncertainties and data needs were identified as a result of this effort and this alone may provide sufficient value to justify the document and approach. For example, the authors note that there is not an abundance of chronic toxicity data considered in deriving the EPA's ambient water quality criteria for copper and that there is an uncertainty associated with whether the biotic ligand model (BLM) adequately protects species of concern in Bristol Bay. It would seem appropriate for EPA (perhaps in concert with industry) to develop the data to improve our understanding of copper toxicity and to ensure that regulatory standards are, in fact, appropriate for their intended use. A substantial body of data evaluating copper chronic toxicity has been developed by the copper industry as a result of regulatory requirements driven by the European REACH regulations. It may be beneficial for EPA to examine these data, thus resulting in a reduction in any uncertainty associated with the evaluation of environmentally acceptable metals concentrations. It should also be noted that similar datasets and biotic ligand models exist for number of other metals that may be of concern at the Bristol Bay site.

One suggestion that would improve the document is that EPA should include a basic description of the risk assessment process and the relationship between the risk assessor and the risk manager, i.e., the decision maker. They must include a discussion of why the assessment is being conducted, the decisions that will be informed, and what information they need from the risk assessor.

Taken from the USEPA's Guidelines for Ecological Risk Assessment (EPA630/R-95/002F; April 1998). Note 2nd sentence re: the role of the risk manager.

> *"2.1. THE ROLES OF RISK MANAGERS, RISK ASSESSORS, AND INTERESTED PARTIES IN PLANNING*
>
> *During the planning dialogue, risk managers and risk assessors each bring important perspective to the table.* ***Risk managers, charged with protecting human health and the environment, help ensure that risk assessments provide information relevant to their decisions by describing why the risk assessment is needed, what decisions it will influence, and what they want to receive from the risk assessor.*** *It is also helpful for*

managers to consider and communicate problems they have encountered in the past when trying to use risk assessments for decision making.

In turn, risk assessors ensure that scientific information is effectively used to address ecological and management concerns. Risk assessors describe what they can provide to the risk manager, where problems are likely to occur, and where uncertainty may be problematic. In addition, risk assessors may provide insights to risk managers about alternative management options likely to achieve stated goals because the options are ecologically grounded."

Dirk van Zyl, Ph.D., P.E.

Planning and designing a large mine, and especially one in a sensitive environmental setting such as Bristol Bay, involves many iterations before a design evolves that is provided for further public considerations. The EPA elected to use a design, developed for Northern Dynasty Minerals Ltd. in a preliminary assessment prepared following the guidance of National Instrument (NI) 43-101, as the basis for extensive evaluations in their risk assessment. The resulting risk assessment can be at best characterized as preliminary, screening level, or conceptual. There are both technical and process issues that must be addressed before this risk assessment can be considered complete or of sufficient credibility to be the basis for a better understanding of the impacts of mining in the Bristol Bay watershed.

There are a number of items that require specific attention prior to finalizing the report. While my comments below provide further details, from a global perspective the following aspects must be addressed:

- A better sense about the range of impacts from a mining project that use not only different technologies but also different lay-out options in its development than that assumed in the EPA Assessment;
- More attention to the use of appropriate order of magnitude numbers reflective of the quality of data, e.g. less accuracy is obtained when 1:62,500 scale vs. 1:12,500 scale maps are used;
- Correction of errors associated with misquoting and incorrect use of information in the literature; and
- A critical review and rewrite of the Executive Summary to reflect the tone, terminology, information sources and results of the main body of the report. One example of an error and one of inconsistent terminology are:
  - Page ES-10: "Thus, the mine draws on plans published by the Pebble Limited Partnership (PLP)", this is incorrect as the plans that were used were prepared for Northern Dynasty Minerals Ltd.
  - Page ES-10: "…our scenario reflects the general characteristics of mineral deposits in the watershed, contemporary mining technologies and best practices…" The main body of the report emphasizes on a number of occasions (such as Page 4-1, 4-17) that "Our mine scenario represents current good, but not necessarily best, mining practices".

My comments contained above and below are based on a single review of the report, i.e. contractual time constraints were such that I could not afford a second review of the report. It is therefore possible that there are other errors remaining in the report that I did not observe in my review. It is therefore recommended that after making these corrections and edits that EPA subject the report again to a rigorous independent review.

Phyllis K. Weber Scannell, Ph.D.

My comments on EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* follow a three-day peer review meeting in Anchorage, AK. On the first day of the meeting, the Peer Review Team heard testimony on the importance of the resources in the potentially affected area and on possible effects of mineral development on the fish and wildlife resources and on local residents. The issues of mineral development are complex, particularly with respect to protecting the environment and the interests of local residents. I understand and appreciate the complexity of these issues; however, the charge of the Peer Review Team is to review EPA's draft document, *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska,* and offer suggestions to strengthen the report. My comments, included below, are focused on the accuracy and thoroughness of the draft document.

The document "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" and the accompanying appendices provide an in-depth and thoroughly documented description of the environment and resources of the areas under consideration for mineral development, although not in the entire Bristol Bay region. Appendices A and B are particularly thorough in describing the salmon and non-salmon fishes in the region; the discussion of species specific fish sensitivities to certain toxicants adds important information for future consideration of project development.

The assumptions for developing and operating large porphyry copper mine may not be aligned with features of a future mining project. Too much emphasis was placed on effects of catastrophic failures, such as failure of a tailings dam or pipeline, and too little emphasis on the need to identify and control seepage water, run-off from PAG (potentially acid generating) and NAG (not acid generating) waste rock areas, and water treatment.

The document discussed effects of dewatering on suppressing stream flows and groundwater inputs but did not consider effects of the discharge of treated wastewater. The section on hydrology illustrates the need for more complete hydrologic information before any project development. The need for bypassing all clean water sources around a development site should be addressed.

The cultural characterizations and effects on human populations from large mine development are outside my area of expertise; therefore, I cannot comment on the adequacy of the information.

As stated in my response to charge questions, I believe that the two most important questions for mineral development in this region are: can a mine be designed and operated for future closure? and, if not, is it acceptable to develop a large porphyry copper mine in a region of high value salmon habitat that will essentially require perpetual treatment? These two questions must be addressed when considering protection of the fish, wildlife, and human resources of the region.

Paul Whitney, Ph.D.

Response (with a wildlife perspective) – The main document is fish centric and it should be, given the importance of salmon in the Bristol Bay ecosystem. Wildlife (aquatic, wetland and upland species) and terrestrial resources related to potential mine and haul road impacts are glossed over. The summary write ups for several species of wildlife (Appendix C) are very good regarding natural history and some potential impacts. Information in Appendix C tends to focus on the proposed mine site and less on the proposed haul road and game management units in the Kenai Mountains.

A variety of authors have obviously contributed to the documents and it appears that the direction given to them or their interpretation of goal statements varies. For example, if one of the goals of the assessment is to evaluate the risk to wildlife due to risk to fish (Executive Summary, page 1, last para) it's not clear why so much verbiage in Appendix C (wildlife) is devoted to species such as caribou that are not closely associated with fish. Information in Appendix C could be used to assess direct impacts if the scope of the assessment is expanded. For example, if the goal is to assess the impact of potential mining on the ecosystem (see Executive Summary page 1, para 1), the information on caribou in Appendix C is more relevant. The apparent diversity of goal statements cited in the main assessment gives mixed messages regarding the clarity of the presentation (see more detailed discussion below).

The charge question related to wildlife asks for an evaluation of the risk to wildlife due to the risk to fish. If the risk to fish can not be quantified because there is little or no demographic information, then any evaluation of risk to wildlife can't be quantified and must be qualitative. Merely stating that a qualitative increased risk for fish will also result in a qualitative increased risk for wildlife is not adequate. I am not satisfied with such an obvious and general conclusion. I do not understand why the scope of the main document is limited to an indirect evaluation of fish-caused risk to wildlife. The following responses to charge questions leans more toward an ecosystem evaluation that includes, not only risk of fish to wildlife, but also risk of direct wildlife and vegetation loss to fish and other direct risks to wildlife, such as noise and human presence.

III.2. Responses to Charge Questions

Question 1. The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

David A. Atkins, M.S.

Based on my general understanding of the watersheds, I consider the general background information presented in the Assessment accurate and sufficiently complete for the endpoints of this watershed assessment in the following areas:

- General view of Pacific salmon populations
- General view of resident (non-anadromous) fish
- Wildlife populations
- Native cultures

The Assessment also describes the current economics of the watershed, including commercial and sport fishing and subsistence activities.

Additionally, the report highlights several general aspects of the area that make the fishery unique in both its abundance and diversity:

- The unique hydrology of the area (strong groundwater and surface water interaction) that contributes to stable flows and temperatures favorable for salmon reproduction.
- The importance of anadromous fish in transferring marine-derived nutrients to upland areas and thus providing nutrients to areas that would naturally be nutrient poor.
- The lack of roads and infrastructure that make the area unique as one of the few intact ecosystems remaining in the world, and possibly unique for this type of fishery.

It would be helpful in the background section to better describe the uniqueness of the Bristol Bay watershed ecosystem in the Pacific Northwest. This could include a description of other similar ecosystems in the region that have undergone development and documentation of any changes in fish populations associated with this development. The Assessment does mention the Fraser River as an analogue, but the scale of development in this watershed, and even the success of the salmon fishery, seems to be a point of contention, with some saying mining and fish coexist, and other saying the impacts are severe.

It would also be helpful to better explain fish resources in the proposed project area in comparison to other areas within the watershed. I understand some of the necessary data may not be available for the project area. It would be helpful to know, however, if the habitat in the project area is typical, exceptional, or inferior to that in other areas of the watershed.

Regarding geological resources, the report describes the Pebble deposit and five other mineral deposits in the Nushagak and Kvichak watersheds. It would be helpful to know if there are other mineral resources or oil and gas resources in the Bristol Bay watershed as a whole that could also be exploited. It would also be helpful to describe the portion of the watershed that is off-limits to development due to park and protected area status vs. those lands that are open to mineral development.

Steve Buckley, M.S., CPG

The background information presented in the characterization of the ecologic, hydrologic, and geologic resources is overly broad in scope. Specifically, the descriptions of the relationship between landforms, streams, and surface water and the interaction with groundwater are mentioned as very important to fish in the watersheds, yet there is insufficient detail to assess these interactions and consequently, the characterization of these resources is weak. There is more detailed information available in the Environmental Baseline Document (EBD) regarding the relation between landforms, streams, groundwater, and fish habitat in the watershed.

Courtney Carothers, Ph.D.

The background information presented on the ecological and geological resources of the Nushagak and Kvichak watersheds appears to be appropriate and accurate. The report notes that there is a lack of quantitative data on salmonid populations in this region, a lack of a full identification and characterization of salmon presence, spawning, and rearing areas, and a lack of detailed understanding of how local stream and river system features (e.g., temperature, habitat structure, predator-prey relationships, limiting factors) affect salmonid production in the region. Further, climate change is noted to be affecting local conditions. These unknowns are important to stress throughout the report.

The cultural characterization presented in Appendix D presents detailed information on historical and contemporary Yup'ik and Dena'ina communities of this region, stressing the centrality of salmon and subsistence in these cultures. This assessment benefits from the time-depth of relationships developed by Boraas and Knott. Overall, this section of the report is based on standard ethnographic methods, although the research design and analysis could be explained in more detail (and described in a separate methods section). The "voices of the people" sections are helpful to present directly the perspectives given by local people. These quotes reveal the complexity of subsistence and contemporary village concerns in this region. At times, the cultural assessment can minimize this complexity.

As detailed in the specific comments below, potential risks and impacts to subsistence are underestimated and at times framed in the report as primarily ones of physical health and economic factors. As described in Appendix D, harvesting, processing, sharing, and consuming wild foods are central to social, cultural, spiritual, psychological, and emotional well-being in Yup'ik and Dena'ina cultures. The subsistence lifestyle is considered central to the health of the people and communities of this region. This is particularly important to note for indigenous communities who continue to cope with the legacies of colonialism. This point is made in Appendix D (but at times could also be strengthened there, as suggested below), and is articulated in some of the quoted interview material.

Recent data on subsistence harvests, use areas, and local context collected for the PLP Environmental Baseline Document (as well as evaluation and discussion of such data, e.g., Langdon et al. 2006) and by the Alaska Department of Fish and Game (e.g., Fall et al. 2012) would be a useful addition to the cultural characterization. Other studies of local traditional ecological knowledge (e.g., Kenner 2005) may help to supplement the assessment of the abundance and distribution of fish species in this region, or to supply information on other less-studied freshwater fishes. Recent research on the contemporary salmon-based livelihoods of the region (e.g., Holen 2011, 2009a, and 2009b; Hebert 2008; Donkersloot 2005) would also be helpful to include. An inclusion of case studies of salmon-based cultures that have suffered depletions of their resource base would add to the presentation of likely fish-mediated impacts to culture (e.g., Colombi and Brooks 2012).

Appendix E also characterized the economic baseline of the region. Why is this dimension not asked about here?

Dennis D. Dauble, Ph.D.

As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of non-salmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay watershed (including the Nushagak River and Kvichak River watersheds) is not described in any detail there or in the main report. Available data on known or perceived ecological interactions among salmonid and resident fish should be included in the assessment.

Another limitation to the salmon-centric assessment is that risk assessment endpoints, described in Chapter 3 of the main report, do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes of aquatic communities. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. What nutrient levels occur in these stream systems with and without MDN?

A description of major groups of aquatic invertebrates in terms of biomass and seasonal abundance should be included in the main report. Further, aquatic and terrestrial food webs and linkages need more embellishment. One approach might be to add narrative text with the conceptual model discussion, including descriptions of community structure, function, and biomass.

More detail on river and lake limnology would be helpful. For example, the hydrology of the watershed is mainly limited to a brief discussion of salmonid habitats. The geology of the basin emphasizes geology of mining areas and mineral processes. A more landscape-based description is warranted given the importance of geology to surface water processes and groundwater movement. The report would benefit from having a summary table listing lake size/volume and river length/discharge for watersheds potentially affected (and not affected) by mining activities.

Also missing were specific habitat requirements for rearing of juvenile salmon. A brief description of where pink and chum salmon spawn and rear in the Bristol Bay watershed relative to other salmon species should be included in the main report. There was nothing in Appendix A on where coho, pink, and chum salmon reside within the Bristol Bay watershed.

Each appendix has a wealth of supporting information and could serve as a stand-alone document. However, having to work back-and-forth between the main report and appendices to interpret critical aspects of the assessment presents a challenge. Don't assume the average reader will read (and interpret) these appendices. To help remedy, the authors of the main report should strive to directly cite relevant information (and/or a specific appendix) that supports their conclusions.

Gordon H. Reeves, Ph.D.

The assessment, which included the report and appendices, was comprehensive and thorough regarding the ecological resources of the Nushagak and Kvichak watersheds. The best available data on fish numbers and distribution (Alaska Dept. of Fish and Game's aerial escapement counts, records from the Anadromous Waters Catalog and Alaska Freshwater Fish Inventory, and the Environmental Baseline Document of the Pebble Limited Partnership (2011)) were used for the assessment. These data formed the foundation for much of the assessment on potential impacts to anadromous salmonids and their freshwater habitat in these watersheds and their characterization appeared to be accurate. The authors also appeared to have thoroughly identified and considered all of the appropriate literature.

I am not familiar with data available for the other resources and am thus unable to assess their appropriateness.

Charles Wesley Slaughter, Ph.D.

If only Volume 1 (the Main Report) is considered, the characterization of some aspects of the Nushagak and Kvichak watersheds would have to be termed cursory. Chapter 2, Volume 1 (Characterization of Current Condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region. Similarly, Volume 1 provides a relatively superficial discussion of non-fish wildlife concerns, or human/cultural concerns

By contrast, the information provided in Appendices A-H appears to be comprehensive and complete for each subject field. (Appendix I appears to be a general "template" summary, not tailored to the Bristol Bay watershed environment).

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate a full analysis of these aspects.

John D. Stednick, Ph.D.

The site characterization needs to be expanded. The report needs to better characterize the physical setting. There are a variety of data sources that can be used to better describe the physical setting. It would be useful to see geology, geomorphology, soils, vegetation, digital elevation maps, hypsometric curves of the watersheds in question, streamflow data, and precipitation data—especially storm events and water quality data for surface and groundwater over time and space. Various geographical information system maps would be useful here.

The salmon populations and habitat linkage needs to be better documented since many of the mine impacts are resulted from hydrologic modification. Figures 3-2A to 3-2E represent good thinking and an understanding of the linkages and potential effects of mining on these resources. The linkages to indigenous peoples is illustrated in Figure 3-2E, but little text is presented, referring the reader to the Appendix. The other conceptual models are not adequately addressed in the text. These flow charts provide an opportunity to present processes and linkages as related to potential effects of mine development activity and need to be developed within the text. Indeed, they seem to stand alone with little discussion of potential effects. Additionally, not all charts have adequate materials in the appendix for coverage, thus the variability in resource coverage is inconsistent and infers either a writing bias or data (lack of) bias.

The assessment concludes that a hydrologic modification will have detrimental salmon habitat consequences. The groundwater contributions to streamflows are important, both hydrologically and ecologically. Additional streamflow and groundwater data are needed to represent this linkage. Similarly, additional water quality data over time and space are needed and should include water hardness for metal standards. Depth to groundwater as related to streamflow, age dating of waters, and streamflow modeling would all be useful to illustrate the groundwater upwelling and hyporheic exchanges.

Site disturbance will be significant, yet there is no discussion of soil erosion. Soil erosion and subsequent suspended sediment transport would have the potential to have significant effects on water quality, channel delivery efficiency, salmon, salmon habitat, and metal transport. There is a generic discussion of road construction related to erosion, but road standards, road location, road usage, road maintenance (salting, grading, or watering), and length of roads would help in the risk assessment.

Are any endangered or threatened species present, either state or federally listed?

Roy A. Stein, Ph.D.

Overall Characterization. The characterization of the resources of the Nushagak and Kvichak watersheds was appropriate and accurate in the ecological arena save for the issues discussed below. Geological and cultural resources seemed adequately characterized, but they are not within my expertise. Finally, given the emphasis on these two watersheds (not the entire Bristol Bay watershed), might there be some consideration of a more circumscribed document title?

Broad Scale Comments:

Global Climate Change I. Risks to salmonids seem far greater than what is reviewed throughout this portion of the document. Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph). Given our current understanding, general changes likely include more intense precipitation events and increased temperature (and then of course, all that follows from these two changes and as models become more sophisticated, more specific geographically localized impacts could be assessed). With more intense storms come a greater likelihood of a failure of Tailings Storage Facilities (i.e., commensurate with more frequent and more intense flooding), more acidity from Pre-Tertiary waste rock (which will enter quite vulnerable, poorly buffered streams), and greater sediment influx into streams (and increasing fines in the gravel by as little as 5%, quite a small proportion, "…causes unacceptable effects on salmonid reproduction" (page 8-6; also see Chapter 7), which could occur during "routine operations", especially in light of the fact that sediment influx into streams is a cumulative process). Increased stream temperatures, depending on the absolute increase over a period of 78 years (and beyond, see "in perpetuity" comments below), could lead to reductions in salmon spawning success, as extant populations are specifically adapted to the current temperature regime. As is apparent, both increasing intensity of storms and increasing temperature will likely compromise salmon spawning success, and growth and survival of their offspring in the freshwater environment of Nushagak and Kvichak rivers.

What this would entail, at the very least, is a discussion of a monitoring system to quantify the impacts of Global Climate Change whose impacts on the ecosystem can then be differentiated from mine impacts. My concern is that if the mine is built, all negative impacts of the mine on salmonids, etc., could be attributed to Global Climate Change rather than the true culprit which would be the mining activities.

Global Climate Change II. Indeed, climate change is affecting Alaskan salmon as demonstrated (in a paper that just appeared online July 11, 2012) by a loss of a late-migrating population of pink salmon in a small stream near Juneau, in favor of an early-migrating one. Genetic evidence supports this explanation for Kovach et al. (2012) had 17 generations of data (since 1979) showing the reduction of the September spawners in favor of the late-August ones in response to increasing stream temperatures. As Kovach et al. (2012) write in their concluding paragraph:

> "We no longer observe the clear phenotypic distinction between early- and late-migrating individuals that was once present in the system. Apparently, the very-late-migrating phenotype has been greatly reduced or potentially lost. Although microevolution may have allowed this population to successfully track environmental change, it may have come at the cost of a decrease of within-population biocomplexity – the loss of the late run. This is not a surprising result; by definition, directional selection will decrease genetic variation. However, it does highlight the importance of maintaining sufficient genetic and phenotypic variation within populations in order for them to have the ability to respond to environmental change."

The ramifications of this work are obvious. As pointed out in the report (pages ES-8, 2-22, 5-28 as just a few examples), the exceptional quality of the Bristol Bay salmon stocks depend on the pristine quality of a set of quite diverse aquatic habitats, which has led to the development of genetically diverse stocks of salmon within species, each uniquely adapted to particular habitats. Reducing this variability by mining on top of the rivers that produce >50% of the wild sockeye salmon in Bristol Bay serves to reduce the flexibility with which these stocks respond to any environmental change (most notably Global Climate Change), and most notably during the time course of the Pebble Mine.

Groundwater Exchange. One of the key aspects of this system is the importance of groundwater exchange with surface streams and this groundwater contributes mightily to salmonid egg incubation success and survival (page 2-21). Simultaneous with this is the fact that the water demands of the proposed mine will require more than just surface waters available to it, but rather the mine will have to exploit groundwater resources to support its operations. This is yet another risk to salmonid success for reduction in the availability of groundwater will lead to increased temperatures in summer (see pages 3-7, 5-28, 5-29) and less inviting overwinter habitats (pages 5-20, 5-29), further exacerbating both mining and climate change effects.

Exploration Effects. During the public testimony segment, several Alaskan Natives argued that impacts owing to exploration have already occurred. A series of points were made: 1) exploration equipment was left behind, despoiling the landscape, 2) noise from helicopters frightened moose making them less vulnerable to exploitation, and 3) habitat change has already begun just due to exploration activities.

"In Perpetuity." Following up on the idea of increased risk (see previous points) to salmon, I struggled with the idea of this mine being monitored and maintained "in perpetuity" (e.g., pages ES-2, 4-32, 4-34). First, this relates directly to the Global Climate Change issues, in that these changes likely will continue to build through time, further exacerbating negative impacts on salmon. Even without climate change, salmon are in peril from mining operations in the Nushagak and Kvichak rivers; with climate change, the cards are stacked against them.

Second, what regulatory or institutional mechanisms currently available place the responsibility of these efforts on the corporation "in perpetuity"? Because mining companies come and go, might there be mechanisms that come into play if this particular company goes bankrupt? Might there be some sort of bonding process that protects the environment from the mine's remains into the long-term future? If not, should new legislation be pursued? Acknowledgement of this important issue should be front and center in the document, in my view.

Third, I began the review process with idea that the mine would be built, would capture its resources, and then would end by restoring the site. The scenario that includes monitoring and maintenance 1,000 years into the future continues to bother me. One solution that comes to mind is that Federal or state government would be charged with these monitoring and long-term maintenance activities, paid for by a hefty tax on the minerals removed from this site.

Finally, I am not encouraged by any of the text surrounding this issue, the two most relevant quotes (pages 4-31 and 5-45, respectively) being:

> "There are no examples of such successful, long-term collection and treatment systems for mines, because these time periods (100's to 1000's of year) exceed the lifespan of most past large-scale mining activities, as well as most human institutions."
>
> "We know of no precedent for the long-term management of water quality and quantity on this scale at an inactive mine."

And, finally, a quote from Chapter 8 on page 8-13:

> "The promises of today's mine developers may not be carried through by future generations of operators whose sole obligation is to the shareholders of their time (Blight 2010)."

William A. Stubblefield, Ph.D.

The EPA's assessment document presents a seemingly comprehensive compilation of the data associated with the ecological, geological, economic, and cultural resources of the Bristol Bay area. The characterization as presented seems to provide appropriate background information for the assessment considering the hypothetical nature of the evaluation. Without having specific knowledge of the area in question, it is not possible to provide an assessment as to whether the characterization was accurate. I'm unaware of significant literature, reports, or data that were specific to the site and would be useful for consideration. The assessment should be expanded to include greater detail regarding the environmental aspects of the site.

Dirk van Zyl, Ph.D., P.E.

The geological information was taken from documents prepared to conform to and in compliance with the standards set by National Instrument 43-101 (NI 43-101) (Ghaffari et al., 2011). This regulatory instrument emphasizes resource information for projects. While I cannot comment on the accuracy of the regional geological information, the document should reflect accurate geological information of the Pebble District as known at the time when the report was prepared.

My review did not include the Environmental Baseline Document (EBD) of the PLP. However, in scanning that document, it seems that more site-specific information on site hydrogeology may be available than was described in the EPA Assessment. While the latter refers to the EBD extensively in terms of fish populations, etc., it does not refer to it for much of the site physical characterization. EPA should address this in edits to the Draft Assessment.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment presents a well-documented discussion of the fish and wildlife resources of the Nushagak River and Kvichak River Watersheds, with more limited discussions of the remainder of the Bristol Bay Watershed. The document discusses interactions among species, including nutrient flows and the importance of groundwater systems; however, information on contributions of marine-derived nutrients and existing pressures on the environment are not as complete, or lacking. The information is general in nature. Should mine development go forward, it will be necessary to obtain ecological information specific to the potentially affected areas. The information should include timing of fish spawning, egg hatch, in-migration and out-migration, and similar specific life-history information for important wildlife species.

The discussion on the cultural resources is outside my areas of expertise and I cannot provide meaningful comments.

Paul Whitney, Ph.D.

Fish Population Estimates. There are several places in the text where impacts of the loss and degradation of habitat on fish populations was not quantified because of the lack of demographic data for salmonids (e.g., page ES-26, third bullet). These statements are only partially accurate. It is true that population models such as life tables or Leslie matrices require population age class data to estimate population numbers. However, even if demographic data are available, these population models do not relate population estimates to habitat quality. Incomplete data and relating fish population estimates to habitat quality are not an uncommon problem in ecology and there are many approaches for dealing with this issue. Approaches such as Ecosystem Diagnosis and Treatment (McElhany et al. 2010), Expert Panels (Marcot et al. 2012), Bayesian nets (Lee and Reiman 1997), Discussion with experts (Appendix G), or Weighing Lines of Evidence (Section 6.1.5) are just some of the methods for relating habitat quality to fish abundance. Models and expert opinions, of course, bring their own uncertainties but it seems better to have quantitative estimates (and discussion of the estimates) of all the potential fish losses due to habitat loss than no estimate at all.

Even though the Executive Summary indicates that the impacts of loss and degradation of habitat on fish populations could not be quantified, the text does provide some estimates. For example, the assessment (page 6-11, first full para) estimates "that the combined effects of direct losses of habitat in the North Fork Koktuli, down stream in the mainstem Koktuli and beyond, and impacts on macroinvertebrate prey for salmon could adversely affect 30 to 50% of Chinook salmon returning to spawn in the Nushagak River watershed." This type of statement, and the basis for the statement followed by a discussion of uncertainty, is a good example of the estimates that would better describe possible impacts of the example mine on salmonids. Another example estimate appears on page 6-39 for four species of salmon.

Question 2. A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

David A. Atkins, M.S.

The hypothetical mining scenario presented in the Assessment is based on a "Preliminary Assessment Technical Report" of the Pebble deposit prepared for Northern Dynasty Minerals by Wardrop (referred to as Ghaffari et al. 2011), in conformance with Canadian National Instrument 43-101 (NI 43-101) which is used to set standards for public disclosure of scientific and technical information about mineral projects of companies on bourses supervised by the Canadian Securities Administrators. By most accounts, the Pebble deposit is a world-class deposit and the Wardrop report counts nearly 11 billion tonnes of total resource. It is unlikely that all the ore currently identified would be mined, so 11 billion tonnes would be an upper bound for this particular deposit. It is also certain that exploiting the Pebble deposit would have to be at a scale large enough to justify the capital investment to build an infrastructure in such a remote area. Although the Assessment is ostensibly about any mining development in the Bristol Bay watershed, the use of the Wardrop scenario for Pebble effectively makes the report an assessment of mining the Pebble deposit.

The question then becomes what size mine is feasible from a technical and economic point of view. The Pebble deposit mine plan, as presented in the Wardrop report, outlines three scenarios:

- An "investment decision case" for a 25-year mine life that would mine 2 billion tonnes of ore;
- A "reference case" for a 45-year mine life that would mine 3.8 billion tonnes of ore; and
- A "resource case" for a 78-year mine life that would mine 6.5 billion tonnes of ore, or 55% of the total measured, indicated and inferred resource.

The Assessment chose minimum and maximum mine sizes of 2 billion and 6.5 billion tonnes of ore, respectively. Thus, the resource estimate used for the Assessment is the same as that for the two end members presented by Wardrop. This would make the mine one of the largest in the world, exceeding the size of the 10th percentile of global porphyry copper deposits by an order of magnitude (see Appendix H of the Assessment). Mines that ultimately become this size usually expand by increments, as exploration discovers new ore zones and expansion permits are granted.

The Wardrop report further delineates Pebble West as a low-grade deposit near the surface that would most efficiently be mined using open-pit methods, with Pebble East as a deeper, higher-grade deposit that would most efficiently be mined using underground methods (specifically block-caving). Mine facilities, as outlined in the Wardrop report, would include:

- Open-pit mining utilizing conventional drill, blast and truck-haul methods for near-surface deposits.
- Underground, block-cave methods for deeper deposits.

- A process plant with throughput of 200,000 tonnes/day that utilizes conventional crush-grid-float technology with secondary gold recovery.
- Other mine-site facilities, including:
  - Tailings storage.
  - Waste rock storage (the estimated waste/ore strip ratio is 2:1).
  - A natural-gas fired power plant.
  - Shop, office, and camp buildings.
  - Pipelines to ship ore concentrate slurry to the port facility; return water from the tailings slurry after separation at the port facility; and fuel.

This mining and ore processing approach is conventional, and the Assessment includes these elements. A mine developer may present alternative plans that could vary or alter how the mine is developed, but the fundamental components would most likely remain the same.

Because the Assessment is presented as a general assessment of mining risks and impacts in Bristol Bay and not a specific analysis of the Pebble Project, reliance on the scenario presented in Wardrop makes the assessment overly specific. Further, Chapter 7 provides more specific information on "Cumulative and Watershed-Scale Effects of Multiple Mines," which presents analysis of potential impacts from mining five additional deposits in various stages of development (presumably from early exploration to pre-feasibility). The information presented in Chapter 7 seems more like another mining scenario than a cumulative impacts assessment. Therefore, I would suggest a broader range of potential mining scenarios be organized as follows, with the detail of assessment necessarily becoming more speculative with each subsequent scenario in the list (due to the lack of geologic and engineering information on the other deposits):

- Development of one, average-sized porphyry copper deposit (50^{th} percentile or 250 million tonnes of ore as described in Appendix H) in the location of the Pebble deposit.
- Development of a mega-mine in the location of the Pebble deposit (of the range between 2 and 6.5 billion tonnes of ore) that may develop after multiple expansion and permitting cycles.
- Development of a mining district consisting of an average-sized Pebble mine and other potential mines (i.e., those presented in Chapter 7).
- Maximum development of all identified potential resources to their most likely ultimate extent.

Considering this broader range of scenarios would help the reader to better understand the range of potential risks and impacts.

Steve Buckley, M.S., CPG

Additional mine scenarios are necessary to appropriately bound the magnitude of potential mine activities. The maximum mine size in the mine scenario seems appropriate given the existing public information on the Pebble deposit. The minimum mine size of 2 billion tons exceeds the 90^{th} percentile of global porphyry copper deposits. Using a minimum mine scenario in the range of 250 million tons or in the 50^{th} percentile range of global porphyry copper deposits would be more appropriate to bound the lower end of the magnitude of potential mine activities. It would also be useful to include some variation in mining methods. This could include incremental development of a smaller open pit in the lower grade zones of a deposit, along with a portion of the higher grade deposit being mined by underground block caving methods to further assess the minimum potential impact of the mine scenario.

Courtney Carothers, Ph.D.

The hypothetical mine scenario was closely based on a probable mine prospect under development. As such, it appears to be realistic and sufficient, if challenging to conceptualize as fully hypothetical given this association.

The report notes that the Pebble deposit may exceed 11 billion metric tons (4-17). The rationale for choosing 6.5 billion metric tons as a maximum size is based "most likely mine to be developed (4-19)." The rationale for not choosing a higher potential maximum could be explained.

Dennis D. Dauble, Ph.D.

The hypothetical mine scenario initially appeared realistic and useful in terms of potential project scope. However, it was apparent during the public hearing, and upon further discussion between members of the panel, that assumptions on mine size should be revisited based on deposit characteristics and extraction potential. Also, assumed practices and operations should be verified against current best-practice and State of Alaska permitting guidelines.

Referenced literature provides appropriate context, however, I cannot help believe that information on environmental impacts from past mining activities conducted in the Rocky Mountain metal belt would be relevant to this assessment in some cases. It is also possible that recent published information from Holden Mine in northern Washington State would help establish context for effects of leachates and model results that predict downstream transport of tailing material in a wilderness setting, for example.

Gordon H. Reeves, Ph.D.

I am not familiar with this subject area and unable to comment on how realistic or sufficient the hypothetical mine scenario was.

Charles Wesley Slaughter, Ph.D.

Given the available information base for the ore deposits of the Bristol Bay watershed, and the publicity which has attended the Pebble planned development over the past several years, the Assessment's hypothetical mine scenario seems fairly realistic. Further, it is appropriate that the Assessment consider the probable impacts of other future mineral development projects once an initial entry (presumably Pebble-Northern Dynasty Minerals) has been accomplished. Such subsequent development – "cumulative effects over a long time period" – could (and should) receive **more** emphasis than is accorded in the Assessment.

John D. Stednick, Ph.D.

The document does not adequately bound the range of mine scenarios. The minimum mine development scenario is not adequately addressed. A frequent criticism during the public comment session was that mine plans presented in the assessment are not representative of current standards. A *compilation* of existing world porphyry mine complexes as well as other types of mines specific to Alaska would better inform the reader of mining processes and potential risks. The physical setting in Southwest Alaska is not the same as the Bingham Mine in Salt Lake City. Currently, the document refers to a particular mine in a particular risk assessment (stressor), e.g., the Fraser River for salmon, Aitika for chemistry, and Altiplano for pipeline failures.

The Bureau of Land Management has identified certain lands that will be excluded from development. This reference needs to be followed up.

Roy A. Stein, Ph.D.

Hypothetical Mine Scenario. Though mining does not lie within my area of expertise, I thought that this scenario helped me understand the potential impact of a mine of this magnitude in a wilderness, pristine watershed. I find it difficult to comment as to whether this scenario is realistic and sufficient, though I did use this scenario to guide my comments below. From the text, it is apparent that this is a realistic scenario, based on documents filed by the company with the Canadian government. This makes this scenario the most realistic one could expect.

a. **Minimum and Maximum Mine Size.** For me, as an ecologist, this bounding helped me to understand the potential impacts of the Pebble Mine, though I did not understand what the probability of either mine size happening in the near term. Understanding these probabilities would be helpful to the readers.
b. **Mine-Size Continuum**. Is it more likely that the initial Pebble Mine will be maximum or minimum in size? Wouldn't it be far better to review a continuum of mine sizes from the smallest that is economically feasible to one that is intermediate in size and then to one (or two) that would take to the largest realistic mine size? With this continuum, the reader begins to understand the overall impact of various mine sizes on the Bristol Bay ecosystem. Some reflection on these mines sizes and their impacts would have helped me interpret the Environmental Risk Assessment with some additional insight.

One Watershed. Given the productivity of salmon from these two river systems (50% of the sockeye salmon in Bristol Bay are produced from these rivers), might there be some thought given to limiting the mining operations to a single watershed, either the Nushagak or the Kvichak (page ES-2)? In so doing, in a single stroke, the impact of this mine on salmon is reduced by 50% or more. Could the Pebble Mine be confined to one watershed, such as where the majority now falls – in the Nushagak River (both the north and south forks of the Koktull River) watershed? Even so, this suggestion becomes especially pertinent to Chinook salmon spawning in the Nushagak River, for this run is "near the world's largest" (page ES-5), but yet the Nushagak watershed is small relative to other watersheds (such as the Kuskokwim and the Yukon) where Chinook salmon are abundant. As a result, any impacts to the watershed by a mine of this size are magnified, another concern when considering this location. Without mining expertise, I cannot judge whether it would be possible to mine in only one of the watersheds, rather than both. Even so, some consideration should be given to this suggestion.

William A. Stubblefield, Ph.D.

The hypothetical mine scenario proposed in the document seemed plausible; however, the evaluation of the proposed mine is outside my area of expertise and I can provide no judgment regarding its potential realism. Other members of the review panel are more knowledgeable about mine engineering.

Dirk van Zyl, Ph.D., P.E.

The hypothetical mine scenario adopted by the EPA relied almost exclusively on the document prepared for Northern Dynasty Minerals (NDM), one of the partners of the Pebble Limited Partnership. Developing a mine plan for a specific ore body is a large task and is undertaken by a large team of engineers and scientists. In the process of developing a mine plan many options are considered for each facility and its components, including mining methods, process design options, waste rock management options, tailings management options, shipment of product, etc. The hypothetical mine scenario was prepared by an independent consulting company for one of the partners and this plan does not necessarily represent the design and management options that will be selected for developing this ore body. Because of ore grades and the deposit style, it is most likely that an open pit mine will be developed as assumed in the report for the western lower grade ore body and that underground mining will be used for the eastern higher grade ore body. The size of the ore body and the strip ratio for an open pit mine are completely dependent on metal prices and production costs at the time of mine development. Metal prices and production costs will also be a major factor in deciding whether to first develop an underground mine instead of an open pit mine. While some of the components of the final mine <u>may</u> contain elements of the conceptual mine, it is impossible to know whether the hypothetical mine scenario is realistic, as will be further discussed in the comments below.

To address the issue of sufficiency it is necessary to understand the range of potential outcomes related to the various options. For the most part, the EPA study used the information from the NDM document for evaluating impacts to salmonids. Using different options, both technological as well as site selection, for some or many of the facilities could result in impacts that are different from those described in the report. I would therefore suggest that using only the present hypothetical mine scenarios is insufficient. There could be a range of impacts, such as the surface areas of facilities, which in some cases could be smaller than what was chosen and in other cases larger. However, this does not mean that the hypothetical mine represents "average conditions." I therefore consider the mine scenario not sufficient for the assessment.

The minimum and maximum mine sizes selected by EPA are 2 billion tonnes mined over 25 years and 6.5 billion tonnes mined over 78 years; in both cases, the daily ore processing rate is 200,000 tonnes. As indicated above, the final economic mine size at the time of development will be determined by metal prices and production costs. Note that production costs, as used here, include all the considerations related to regulatory, environmental and social aspects of the mine and its environs. Mining companies typically make investment decisions for periods of 20 to 30 years. It is seldom, if ever, that a new investment will be made based on a 78 year mine life; however, the upside potential will be taken into account when an investment for a shorter mine life is made. It is also unlikely that environmental regulatory agencies will consider issuing a permit, including closure plans, etc. for a 78-year project. Furthermore, even if the mine ultimately continues for 78 years, it is certain that the operating and environmental control technologies and societal expectations will change in that period and therefore the elements used by EPA for the maximum size hypothetical mine will certainly not be valid for such a long mine life. It is therefore my conclusion that assuming the development of a 2 billion tonne ore body is realistic, but that assuming development of a 6.8 billion tonne ore body, using static technology assumptions, is not.

The EPA assessment report includes a range of the literature and reports in evaluating the selected mine scenario. However, I have a number of specific comments about various aspects of the report as well as the references.

Good practice vs. best practice. On p. 4-1 of the report, the EPA states: "Described mining practices and our mine scenarios reflect the current practice for porphyry copper mining around the world, and represent current good, but not necessarily best, mining practices". EPA does not clarify this decision, nor does the report clarify the distinction between "good" and "best" practices. It can only be concluded that "best" will be better than "good". On the basis of this, it is inconceivable to me that the Bristol Bay communities, the Alaska regulatory authorities as well as Federal Regulatory Authorities will not demand that the company follow "best mining practices", however that is defined at the time. It is also inconceivable to me that the company will not follow "best mining practices" in the design and development of such a mine. During the engagement processes, the stakeholders will have to agree what represents "best" practice in the design of the mining project. It is important to note that most of the failure statistics used as a basis for the evaluations in the report are derived from data gathered over the last 50 years or so (e.g. refer to p. 4-45 of report). It may be argued that this information is mostly for mines following "good" practices and, in many cases, for projects that had a lower standard of care. To my knowledge, there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices, whatever definitions are used for "good" and "best".

Mine scenarios. The executive summary indicates (p. ES-11): "The mine scenario includes minimum and maximum mine sizes, based on the amount of ore processed (2 billion metric tons vs. 6.5 billion metric tons), and approximately corresponding mine life spans of 25 to 78 years, respectively". This seems to indicate that the mine life cycle in the first case consists of 25 years of operational life followed by closure and, similarly for the second case, 78 years of operational life followed by closure. However, a careful review of the water management section (section 4.3.7) indicates that this is not the case. The EPA water balance calculations are simplified to a set of deterministic values in Table 4-5 for four water management stages during the overall mine life cycle: start-up, operations minimum mine (25 years), operations maximum mine (78 years), and post-closure. For post-closure, only the 78-year mine life numbers are used. It therefore seems that EPA is not considering that the 25-year mine will close, but that its life will automatically be extended to 78 years. Does this mean that the EPA really does not evaluate the minimum mine size completely, i.e. the 25-year mine life followed by closure? It is important that this be clarified as it would be inconsistent not to evaluate closure of the 25-year mine. It is possible that additional evaluations, or at least additional explanations, will be required to clarify this.

Tailings management technologies. Ongoing technology development has resulted in a broader range of tailings management options than only slurry tailings disposal. Filtered dry stack tailings can be considered as a realistic option, even for mines with higher production rates. Flotation of remaining sulfides in the tailings before deposition is also a realistic option for mines; it has been done successfully at the Thompson Creek Mine in Idaho for the last 18 plus years. While these technologies are mentioned, they are not selected for reasons such as technology not being appropriate for the climatic conditions and concerns with disposal of pyrite waste. Both of these are not insurmountable technical issues and adopting such management options will reduce failure probabilities and potential impacts following a failure. The failure mode of a filtered dry stack facility not containing sulfides will be completely different from a slurry impoundment and the potential environmental impacts of these other tailings management options will definitely be far smaller than those for the selected mine scenario using slurry tailings disposal.

Waste rock management. The waste rock management plan on p. 4-13 calls for the potentially acid generating (PAG) waste rock to be separated from the rest of the waste rock and states that the "PAG waste rock might be placed in the open pit at closure to minimize oxidation of sulfide minerals and generation of acid drainage". However, on p. 4-33 it is stated that: "PAG waste rock will be processed through the flotation mill prior to mine closure, with tailings placed into the TSF (tailings storage facility) or the mine pit." These two alternatives represent completely different management, economic and environmental conditions and are not consistent. Milling the PAG waste rock represents a higher cost than placing the PAG rock in the pit and placing the PAG waste rock tailings in the TSF will increase the size of the TSF. Placing the PAG tailings in the pit will set up a completely different management scenario than placing the PAG waste rock in the pit. The EPA should clarify which option or range of options they select for evaluation and use that consistently in the assessment.

Water balance and management – waste rock. Mine site water balance and management is a very complex issue as recognized by the EPA on p. 4-27: "…water balance development is challenging and requires a number of assumptions". Because of these uncertainties, complex probabilistic dynamic models are employed at mines where the site details are better defined than that of the EPA hypothetical mine scenario. The information in Box 4-2 indicates that the "captured flows include water captured at the mine site and the TSFs (Table 4-5). The total amount of water captured at the mine site includes net precipitation (precipitation minus evapotranspiration[1]) over the areas of the mine pit, the waste rock piles, and the cone of depression (without double-counting any areas of overlap)". On p. 4-23 it is stated that: "Monitoring and recovery wells and seepage cut-off walls would be placed downstream of the piles to manage seepage, with seepage directed either into the mine pit or collection ponds". Figure 4-9 shows this schematically where leachate from the waste rock enters the groundwater that then flows to the mine pit or to the monitoring and collection well. However, if net precipitation only includes the components above (precipitation minus evapotranspiration), effectively excluding infiltration, and if this net precipitation is captured from that waste rock pile (as stated in Box 4-2), then there should not be any water available to infiltrate into the waste rock pile, i.e. there should not be any leachate. All references to seepage from the waste rock piles are incorrect following the EPA's assumptions of total capture of net precipitation. In addition, the approach that is used in the water balance is inconsistent with observed field performance and descriptions in the literature, as is it difficult to imagine a case where there is zero infiltration into a porous waste rock pile (e.g. Nichol et al., 2005 and Fretz et al., 2011). The EPA must clarify the whole water balance model and the evaluations. For the assessment to have any credibility, the water balance and management evaluations should reflect <u>realistic</u> conditions.

Dam failure – tailings storage facilities. During operations, "water falling within the perimeter of a TSF would be captured directly in the TSF, but runoff from catchment areas up-gradient of the TSF would be diverted downstream" (p. 4-27). At closure, water would be removed from the TSF providing more storage, but also maintaining a small pool to "keep the core of the tailings hydrated and isolated from oxidation" (p. 4-32). This seems to assume that the diversion systems will be kept in place and most likely will be upgraded to divert up-gradient surface water around the tailings impoundment. It is likely that the design criterion for the upgraded diversion system during the post-closure period will be the probable maximum flood (PMF) as is done at a number of mines. Dam failure analyses were done assuming that the flood leaving the TSF includes the

[1] During operations most of these areas will not be covered with vegetation and the correct terminology here is "evaporation". The correct terminology is used on p 6-37 of the EPA assessment.

PMF inflow from the up-gradient catchment, excess water on top of the tailings and 20% of the tailings volume (Box 4-8). While one can argue that a failure including all these materials may be a plausible, although a very low likelihood event during operations, it seems less probable that such a failure will take place for the mine closure period when an upgraded diversion system is in place. Also, during the closure phase, the tailings will consolidate and be less mobile. Note that the densification behavior of oil sand tailings referred to on p. 4-32 (i.e. the Wells, 2011 reference) does not apply to copper tailings. The presence of clay minerals and bitumen in the mature fine tailings portion of the oil sand tailings is the source of the different behavior (Znidarčić et al., 2011).

Reclamation slope of waste rock. On p. 4-32 it is stated that: "We assume that NAG waste rock would be sloped to a stable angle (less than 15%) (Blight and Fourie, 2003)". I contacted Profs. Geoff Blight and Andy Fourie about this statement and received the following response from Prof. Blight: "The only reference to 15 degrees (not 15 %) slopes is the following, talking about the outer tailings, not waste rock covered, slopes of decommissioned TSFs: "it must be remembered that the outer slopes will need to be rehabilitated, and that for vegetation to be stable, and surface erosion minimal, the maximum outer slope should not exceed 15 degrees." This error in reference must be corrected; it is recommended that more typical closure slopes of about 30% (or 3H:1V, about 18 degrees) for waste rock should be used in the evaluations.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment discusses a hypothetical mine (given that mine plans have not been developed). Page 4-5 of the document states that "rocks associated with porphyry copper deposits tend to straddle the boundary between net acidic and net alkaline . . ." The Pebble Project Environmental Baseline Report (SRK 2011, Chapter 11) summarizes testing on the samples from the pre-Tertiary porphyry mineralized rock in Pebble East Zone (PEZ) and Pebble West Zone (PWZ). The metals leaching/acid rock drainage study showed acidic conditions occurring immediately in core with low NP, but the average delay to onset of acidic conditions was estimated to be about 20 years. Copper was leached in the highest concentrations, but Co, Cd, Ni, and Zn also leached from samples from PEZ. Wacke (sedimentary rock) samples from PEZ and PWZ leached As, Sb, and Mo, in addition to Cu. (SRK, page 58). The available information on acid generation and metals leaching appears to be preliminary. Development and permitting of a viable mine plan will require extensive sampling and data analysis of ore samples, plans for classifying waste rock (as PAG and NAG), and, possibly, plans for collecting and treating runoff and seepage waters.

The Environmental Assessment seems a bit premature in making an assessment of the potential for acid rock drainage (ARD) or metals leaching (ML). Data on metals other than Cu are insufficient and possible toxicities to fish are not addressed. Further, the description of the potential mine may not reflect a likely mine scenario. It is difficult to calculate potential risks to the environment without a specific mine plan. The section of the Environmental Assessment should be revised as more data on ARD and ML become available.

Paul Whitney, Ph.D.

Reclamation Plan. I am not familiar with the Northern Dynasty Minerals mine plan. I wonder if their mine plan includes a Reclamation Plan. If not, why not? If their mine plan includes a Reclamation Plan, why isn't it presented as part of the Bristol Bay Assessment? The feasibility of reclaiming the waste rock and tailings areas and possibility the pit (page 4-23, last para, last sentence) seems important for evaluating the acceptability of the example mine. I am not aware of any mine regulating agency that does not require a Reclamation Plan as part of a mine application. I wonder if a Reclamation Plan that involved placing waste rock and tailings back in the pit and reducing surface infiltration would greatly reduce the need for water treatment.

Best Mining Practices. The assessment refers to the example mine plan as having both the "best" mining practices (e.g., page ES-10, five lines from the bottom) and "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). Both of these statements can't be accurate.

Noise Levels. The mine plan should provide information on the location, frequency, and size of blasting, sound level isopleths around the mine, and efforts to minimize sound levels as the mine develops. I wonder if a majority of the sound levels will attenuate as mining activities move deeper into the ground or if will there be a hundred years of blasting at the surface level. The interviews with the villagers indicate that blasting and helicopter noise is a concern (Appendix D, Cultural Characterization, page 94). A characterization of current noise levels in relation to the area and timing of current and past wildlife use would help to determine if the whole or parts of the watersheds are less than pristine.

Water treatment during the winter. I wonder if it will be possible to treat water during the winter. Will such treatment have to occur in a warm building? If so, what are the temperature consequences of releasing warm treated water into streams?

Cone of Depression. I have worked on pit mines where hydrogeologists model the lateral extent of the cone of depression and have mapped the lateral extent as an area around the pit. The lateral extent of the cone of depression, illustrated in Figure 4-9, appears to be underestimated and has no effect on streams or wetlands. The figure has no scale. Is the lateral extent of the cone of depression in Figure 4-9 based on modeling (see Box 4-2, para 3, last sentence)? If so, how many NWI wetlands and meters of stream are in the area used for the model? If there are wetlands or streams in the modeled area, how far down stream will the cone of depression influence stream flow and wetland hydrology?

The information in Box 4-2 doesn't clearly (at least to me) deal with the proportions of run-on and run-off water. If the diverted run-on water is supposed to mitigate the cone of depression. will it be available for down stream resources? Why won't diverted water seep back into the near-by pit versus mitigating the cone of depression? The answer to these questions is on page 5-72, but merely indicating there will be a reduction is not very informative.

Run-on and run-off water terminology. I am used to referring to up gradient or adjacent water that runs onto the pit or tailings facilities as run-on water and to water from the mine or storage facilities as run-off water. The assessment doesn't always distinguish these two types of water. For example, on page 4-13, line 6 refers to precipitation run-off water as up gradient water. On page 4-26, the first bullet refers to run-off water as water running off mine facilities. The terminology overlap makes it difficult (at least for me) to understand how the run-on and run-off water will be captured and diverted around the mine facilities or used for other purposes. In addition to calculations, diagrams of the diversions would be helpful. Will there be parallel diversion ditches around the facilities, one for run-on and one for run-off water? Will one or both of these ditches be lined? How will the water in these ditches be influenced by the cone of depression? These questions are alluded to in the discussion on page 4-27(second para), but are not explicitly addressed. I am sure engineers can and have answered these questions for other mines with water balance analyses. It would be interesting to see an explicit summary of the water balance for the various facilities. Such analyses would be good for the example mine plan during operation and once the mine is no longer a net consumer of water (page 5-44, para 2). Without the water balance analyses, potential impacts are not easily understood or quantifiable.

Some ideas for how to manage and separate run-on and run-off water might help determine which streams might dry up and what type of mitigation measures (i.e., lining ditches) could minimize the impact. In addition, if run-on water can be maintained in a diversion ditch, what is the opportunity for developing a reclamation plan for the ditches? Such plans might be able to minimize and partially compensate for lost reaches of headwater streams.

Protective approach. A "protective approach" is mentioned on page 5-30 (para 3, last sentence). This has something to do with water management and would be good to explain.

Question 3. EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

David A. Atkins, M.S.

The no-failure scenario attempts to quantify the impacts from developing the footprint of the project alone. In reality, various failures and accidents inevitably occur, and they may have a range of impacts from inconsequential to large. So this scenario is presented to describe the minimum impact that could be expected from project development assuming everything works as planned.

The mine will, by necessity, remove those streams and wetlands that are beneath the pit, waste rock, tailings and processing plant development areas. There should be some flexibility in siting facilities other than the pit or underground workings. For the 'no-failure' scenario, the Assessment presents lengths of stream and areas of wetlands that would be lost due to physical displacement of the aquatic resources from mine development and reduction in flows from mine water management. The assessment presents the following resources that would be lost and that have been shown to be spawning or rearing habitat for coho, Chinook, and sockeye salmon, or have resident populations of rainbow trout and Dolly Varden:

	25-year scenario	78-year scenario
Eliminated or blocked streams (km)	87.5	141.4
Reduced flow (>20%; km)	2	10
Eliminated wetlands (km^2)	10.2	17.3

Given the range of uncertainty with the proposed mine plan, presenting stream lengths and wetland areas to the tenth place implies unrealistic accuracy. Significant figures should be checked and consistent throughout the document, and ranges should be presented if known (e.g., results for the pits could be presented with more accuracy since we know where they will be, whereas other facilities that could be located in different areas should be presented with an appropriate range of uncertainty).

The impacts as presented appear substantial, mainly because of the very large nature of the project. However, it would be helpful to describe the significance of this loss, specifically with regard to the following questions:

- What impact would the loss to streams and wetlands have on the fishery within the Nushagak and Kvichak basins?
- Is this loss significant in comparison to the fishery as a whole?
- Are there local communities that could be affected by this specific loss?
- Is fragmentation of the resource from this loss a significant impact (i.e., are there stocks that are unique to the project area)?

There is no discussion of engineering and mitigation practices in this section. The responsible regulatory authority would require the project proponent to present a mitigation plan to compensate for these impacts before permitting. Measures would include minimization of impact through facility siting, reclamation if possible, and compensation if reclamation were not feasible. A thorough analysis of possible mitigation approaches and the likelihood of their success are necessary to fully evaluate impacts from the 'no-failure' scenario.

Steve Buckley, M.S., CPG

The engineering and mitigation designs associated with the no-failure mode of operation are inadequate. There is no detailed discussion of engineering practices. There is insufficient discussion of any potential mitigation measures and there is a lack of any detailed research into applicable engineering and mitigation methods. Appendix I provides some engineering and mitigation practices along with water quality mitigation and monitoring during closure; however, these are not discussed or accounted for in the main assessment document.

Courtney Carothers, Ph.D.

The no-failure mode of operation appears to be described adequately. The engineering and mitigation practices appear to be sufficiently detailed, reasonable, and consistent, although I have no particular expertise with which to evaluate this part of the assessment.

It would be helpful to have a clear statement about how well the local (geotechnical, hydrologic, and environmental) conditions in this region have been studied and characterized. How much is understood about the seasonal variation in these conditions and how those variations would affect these scenarios? How well are statistics from mines and TSFs constructed in very different environments likely to apply here?

Dennis D. Dauble, Ph.D.

The description of the no-failure mode for mine operation appears adequate in terms of potential mitigation measures that might be employed. I have limited knowledge of current engineering practices and subsequent risks to the environment from best practices of modern mines, including those operating under optimal conditions. However, it would be helpful to include a short discussion on which mitigation measures would be most applicable to mining activities in the Bristol Bay watershed.

Gordon H. Reeves, Ph.D.

This is an area outside my expertise and I am unable to evaluate and assess the adequacy of what was presented or the quality of information presented, or to identify potential missing literature.

Charles Wesley Slaughter, Ph.D.

Based on the actual history of other major resource extraction projects in Alaska and throughout the world, a "no failure" assumption seems unrealistic. Rather, the assumption should be that there will be failures, of varying modes and magnitudes, over the life of the project. This reality is recognized in several sections of text.

In some sections in the Assessment, presumed "mitigation practices" are either cursory, optimistic, or so general as to be un-supported. Examples include Section 4.3.7's cursory, generalized statements about handling water: "Uncontrolled runoff would be eliminated…The mine operator would capture and collect surface runoff and either direct it to a storage location…or reuse or release it after testing and any necessary treatment"; "…water from these upstream reaches would be diverted around and downstream of the mine where practicable"; "precipitation would be collected and stored…"; and "Assuming no water collection and treatment failures, this excess captured water would be treated to meet existing water quality standards and discharged to nearby streams, partially mitigating flow lost from eliminated or blocked upstream reaches." Other examples from Chapter 6: "…assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..."

John D. Stednick, Ph.D.

The no-failure mode is not adequately described. Assessment of the effects of the mine is based on large risk failures of low probability and did not include low risk failures of higher probability. The report concludes (and emphasizes) that the mine footprint will disrupt/disturb contributing watershed and wetland areas and result in hydrologic modification. The hydrologic modification affects salmonid habitats, particularly in low flow conditions. Regulatory oversight will include the State of Alaska, and certainly mitigation measures would be required. The task is to address the adequacy of these mitigation measures.

Pollutant/toxicity assessment focused on copper. Other metals can be presented to show the range of metal concentrations for chronic and acute toxicity. Suitability of treatment processes for all wastewaters can be included to address potential effects on receiving waters.

The discussion of roads is mostly related to fish blockage and some soil erosion. Information on current design standards was not included and tended to relay on dated references from logging roads.

There were no engineering or mitigation practices described in this section or in the document.

Roy A. Stein, Ph.D.

No Failure Operations and Their Impact. What about the failure of continued monitoring, of continual inspection, of continual, rigorous oversight? This is more insidious than a catastrophic failure of some sort, but perhaps just as dangerous (in fact, one research geochemist testified during public testimony that of 150 hard-rock mines, none operated without leakage of leachate). How can we be sure that mine operators will be held strictly accountable for their actions with regard to best mining practices (a point emphasized by those who testified in favor of the Pebble Mine that indeed best management practices would be used), meeting all the various and sundry regulations, and communicating all of these activities back to the regulatory organization? Will there be a force of will on the part of EPA or other regulatory body to be sure that all activities of the operator are appropriate and within regulatory limits? The down-side of poor monitoring and lack of rigorous oversight is the loss of salmonid populations. These losses are, in my view, less important than compromising human health and life. Yet, at the Upper Big Branch Mine in West Virginia, dust standards have been exceeded for years, leading to a dust explosion that killed 29 miners on April 5, 2010. In turn, even surviving miners were not immune to these dust impacts, for they suffer from "black lung", a condition that literally shortens their life by decades. In turn, much of the monitoring of these conditions has historically been the responsibility of the owner corporation, rather than an independent regulatory body, much like "the fox guarding the chickens". Here at the Pebble Mine site, where only fish (but, of course, Native Alaskan subsistence users, plus other human users as well) are at stake, would one expect rigorous oversight by appropriate regulatory bodies? Skepticism leads to cynicism when contemplating the Upper Big Branch Mine case history in the context of the Pebble Mine proposal.

Engineering Practices and Mitigation. I did not think that mitigation was well described in text, but Appendix I is quite well developed and was instructive to me as I moved through the documents. I would suggest including the ideas in Appendix I in the mitigation section of the main report. Other comments on mitigation issues can be found below associated with Question 12.

William A. Stubblefield, Ph.D.

It is interesting and appropriate that the EPA has included both modes of operation in conducting this assessment. This approach provides some degree of "bounding" for the assessment; however, the degree of accuracy (i.e., predictability) for either scenario cannot be known at this time. The document appropriately acknowledges that there are a variety of potential mitigating factors (e.g., acts of God, accidents, market changes) that may render the assumptions used in this assessment incorrect.

Dirk van Zyl, Ph.D., P.E.

The no-failure mode of operation failures is based on surface disturbances and potential blockages caused by the various facilities. For example, for the mine pit, TSF and waste rock facility, the surface areas of these facilities are used as a basis for calculating the streams and wetlands affected by the mining activities. While the failure mode is adequately described, engineering and mitigation practices are not adequately described by EPA.

The EPA Assessment states on p. 8-1 "Routine operations are defined as mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standards". The adverse effects listed are: direct impacts as a result of removal of streams in footprint of mine pit and waste storage areas; reduced streamflow resulting from water retention; removal of wetlands in the footprint of the mine; indirect impacts of stream and wetland removal; diminished habitat quality in streams below road crossings; and inhibition of salmonid movement from culverts that may block or diminish use of full stream length.

Any mine in Bristol Bay will have to undergo a rigorous and lengthy regulatory review and permitting process. I do not know of a process that will exclude consideration of the impact of all mine facilities on the streams and wetlands in the region. Therefore, I would suggest that the full implications of "mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standard" should have been addressed in the report. The EPA (2003) document on Generic Ecological Assessment Endpoints for Ecological Risk Assessment specifically details the applicability of Section 404 of the CWA in addressing community and ecosystem-level endpoints. "The CWA provides authority for the Corps to require permit application to avoid and minimize wetlands impacts and requires EPA to develop, in coordination with the Corps, the criteria used for Section 404 decisions. When damages to wetlands are unavoidable, the Corps can require permitees to provide compensatory mitigation". It is unclear why this was not included in the evaluations.

Similarly, one would expect that the regulatory reviews will require that the impacts resulting from loss of streams, streamflow and road crossings will be addressed through engineering designs, proposed mitigation measures, as well as regulatory and community engagement best mining practices (see discussion above on "good" vs. "best" practices).

On p. 4-33, it is stated that "Environmental impacts associated with premature closure may be more significant than those associated with planned closure, as mine facilities may not be at the end condition anticipated in the closure plan and there may be uncertainty about future reopening of the mine". Further text describes potential negative impacts from such a premature closure. One of the outcomes of the regulatory review and permitting will be the establishment of financial assurance that will provide State and Federal Regulatory Agencies with the financial resources to accommodate a closure. These obligations are typically reviewed on a 3 or 5-year interval to also make sure that they are adequate to cover premature closures. If the mining company is still managing the site, then they will have responsibilities under all Federal and State Regulations and the dire picture painted by the EPA Assessment should not come to pass.

Because of this major oversight of the realities when permitting and operating a mine it is essential that the scenarios be reviewed by evaluating the effects that regulatory requirements and resulting mitigation methods would have on the no-failure conditions before completely reworking the no-failure mode of operations and their impacts. Other significant reports and data that should be reviewed include typical permitting documents and resulting requirements for similar mines in the US and Canada to obtain a range of potential outcomes. The results from such an evaluation will also contribute significantly to the discussions in Alaska when the Pebble Mine and other mines in Bristol Bay are brought forward to permitting.

Phyllis K. Weber Scannell, Ph.D.

Chapter 4 provides a detailed description of a hypothetical mine design for a porphyry copper deposit in the Bristol Bay watershed. Some of the assumptions appear to be somewhat inconsistent with mines in Alaska. In particular, the descriptions of effects on stream flows from dewatering and water use do not account for recycling process water, bypassing clean water around the project, or treating and discharging collected water.

Section 4.3.8, Post-closure Site Management, raises critically important issues – can a mine in this area be designed for closure? Is it acceptable to develop and operate a mine that will require essentially perpetual treatment? It is my belief that these are the essential questions that should be addressed during any mine permitting process.

Section 4.3.8.1 raises concerns about long term water quality and quantity from the mine pit. These concerns need to be addressed during a mine permitting process. Pit water quality depends on how the pit is developed, what reclamation will occur, if reclamation will be concurrent with mining, and what kinds of water treatment will be used. Tailings storage facility (TSF) water quality depends on how the mine tailings are managed; it may be possible to use dry stack tailings with sulfide removal rather than submerged tailings.

Paul Whitney, Ph.D.

Mitigation Plan. Most mine permit applications I have worked on include both mitigation to minimize environmental impact and mitigation to compensate for environmental impact. The assessment outlines a variety of mitigation measures to minimize impact, but no compensatory mitigation. This is a concern, for I wonder if compensatory mitigation for the example mine is even possible in the watersheds.

The watersheds are characterized with descriptors such as "pristine" (e.g., page 6-29, last para, second line), "nearly pristine" (e.g., pages 2-25 and 7-2) and "exceptional quality" (page 2-20). It is also stated that the return of the salmon "fuel" (i.e., provide energy to) the terrestrial food web.

If in fact the watersheds are pristine or nearly pristine, the habitat is high quality and there is little, if any, opportunity for compensatory mitigation (i.e., improving low quality habitat) in the terrestrial and fresh water environments. For example, if 55 miles of streams and streamside wetlands are lost to the mine footprint (page ES 15, first bullet), is it possible to find miles of very degraded stream to plan for and implement compensatory mitigation? If one assumes a mitigation ratio of 3:1 for enhancement, one might have to find 165 miles of degraded stream for compensation. I suspect (but don't know) that there are very few (if any) miles of degraded stream where compensatory mitigation could occur in the Bristol Bay watershed(s). If this is the case, it might not be possible to demonstrate no net loss for waters of the US, and this is something EPA should be interested in.

I agree that the ecological resources can be ranked as having high quality because the human footprint on the habitat is small (i.e., few roads and villages), but from an energetics (i.e., fuel) and food web perspective, the pristine characterization may not be accurate. The commercial catch of approximately 27.5 million fish each year (up to 70% of the total number of sockeye produced) is a lot of calories that are not flowing through the ecological foodwebs of the watersheds. Granted, some of the commercial catch (if not caught) might not enter the watersheds, but some and perhaps a lot would, especially in good run years. While the harvest level might be sustainable, the loss of energy to commercial fishing causes pause to characterize the watersheds as pristine or nearly pristine. The potential impact of fisheries on energy flow has been addressed by Pauly et al. (2000) and Libralato et al. (2008). I wonder if it is technically possible that a reduction in the commercial fishery is a compensatory mitigation measure.

<u>Effluent treatment.</u> Water quality information in the assessment for benchmarks, background, and leachate is extensive. A thorough review of the water quality and toxicity information is beyond the scope of work of this review. After several reads of this information, it appears that the work is good for copper. For example, work on salmonid olfaction and copper conducted by McCarthy et al. (2007) is potentially important and is cited. The inhibiting effects of copper on olfactory receptor neurons cited by McCarthy et al. (2007) at or above 2 μg/L are lower than the Alaska hardness-based standards and the biotic ligand model (BLM) standard in Table 5-14, but are above the biotic ligand model standard in Tables 5-15 and 5-16. I assume this is due to differences in binding of copper by dissolved organics but I am not sure. Whether one decides to use the 2 μg/L benchmark, or the even lower BLM benchmarks that are in some cases below background values in Table 5-19, I think the key question is whether proposed leachate processing can cost-effectively achieve benchmarks that hover around background concentrations. The answer is beyond my level of expertise.

I do not agree with the assessment's critical question – whether or not effects are observed at these low levels (page 5-57, Exposure-Response Data from Analogous Sites, second sentence). If effects are observed at background concentrations, it seems unreasonable to ask for an even lower benchmark than background concentrations. The uncertainties assessment at the bottom of page 5-57 also seems unreasonable. The possibility that background concentrations are not protective in particular cases seems highly unlikely for one of the most productive salmon communities in the world.

I can think of many questions that are more critical than looking for effects on salmonids at background or near background concentrations of copper. For example, it might be more important to ask what concentrations of copper will result in a significant impact on the salmonid populations and to ask what impact a mixing zone would have on salmonid populations. Last but not least, what are the potential impacts of all toxics on the many other non-salmonid species?

Question 4. Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?

David A. Atkins, M.S.

For the no-failure mode of mine operation, the risks to salmonid fish due to habitat loss and modification in the vicinity of the project are described in terms of loss of lengths of stream or areas of wetlands. Project proponents state that the mine will only impact a very small fraction of the watershed (under a no-failure scenario). It is important to establish whether the modeled impact (e.g., the loss of 87.5 km of streams) is significant, both in terms of the absolute impact, as well as the effect on ecosystem fragmentation.

In addition, project proponents often state they will preserve and even improve the fishery. As mentioned in the answer to the previous question, it would be helpful to know what kinds of mitigation efforts could be employed – minimization, reclamation and compensation – and have some assessment of the potential effectiveness.

The Assessment determines that construction of the transportation corridor could alter the habitat, chemistry, and the migration path across the corridor for the over 30 streams that the corridor will cross or come near. The report further states that the corridor could affect 270 km of streams below the corridor and 240 km of streams above, but that there is no way to assess the magnitude. Therefore, the impacts of the corridor on fish populations are unknown, and this impact is not described in a way that can allow a reviewer to draw any conclusion.

Further, the references for road design and construction practices seem to be more representative of forest and rangeland roads than the type of road that would likely be constructed for this type of project. It would be helpful to cite experience from other transportation corridors constructed for mining and oil and gas projects and developed recently in Alaska.

Steve Buckley, M.S., CPG

Risks to fish due to habitat loss and modification and changes in hydrology and water quality are overly simplified given the broad parameters used to model these potential risks. More specific details on the water balance would help define potential risks to fish from dewatering and habitat loss. For example, there is no attempt to identify groundwater flow paths or the specific response of various landforms to seasonal changes in precipitation and runoff, yet 34 pages are dedicated to an attempt to quantify these impacts. More detailed information is needed to accurately quantify the changes in anticipated runoff and infiltration in the proposed area to determine potential impacts to hydrology and water quality.

Additional ecological information on the contributing watershed area for each fish bearing stream crossing would help identify the potential impacts to fish due to the construction and operation of a transportation corridor.

Courtney Carothers, Ph.D.

Six key direct and indirect mechanisms are identified to pose potential risk to salmonid fish species: eliminated or blocked streams (87.5-141.4 km), reduced stream flow, removal of wetlands (10.2-17.3 km), indirect effects of stream and wetlands removal (downstream effects likely diminishing fish production), diminished habitat quality downstream of road crossings, and blocked movement of salmonids at road crossings. These mechanisms are described clearly. The report appears to appropriately describe the scale and extent of risks under a no-failure mode of operation, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

The assessment describes the number of stream miles impacted under each mode of operation, including miles blocked and eliminated. Less specific were descriptions of impacts due to sedimentation and leachates. What is lacking is quantitative estimates of spawning and rearing habitat that would be lost relative to the total habitat available. Having this information would help provide perspective of overall risk to individual watersheds and the Bristol Bay watershed as a whole. Risks to salmonid fish due to changes in water quality (i.e., toxic materials) need to consider differences in sensitivity and behavioral response according to salmonid life stage.

Surface water characteristics of site watersheds within the area of probable impact are detailed in Table 5-17, but not so for other streams and lakes in the broader watershed. More information should be presented where available. It is not clear whether potentially affected streams and lakes might be nutrient limited (seems that they might be given their dependence on MDN). For example, include N or P concentrations and some discussion about primary and secondary productivity.

I found risks to salmonid fish due to operation of the transportation corridor well-described with respect to spatial distribution of fish and their habitats.

Gordon H. Reeves, Ph.D.

The potential risks to the freshwater habitat of anadromous salmonids are appropriately characterized and described for the no-failure mode of operation. The report considered the primary potential impacts of mine development and operation that could impact habitat and quantified the impacts where possible. The analyses seemed sound and logical, given the acknowledged limitations about the actual mine location and operation.

One possible factor that could influence the results was the use of the USGS 1:63,360 maps for developing the stream network. These maps generally underrepresent the amount of small streams, which can be ecologically important contributors to the overall productivity of the freshwater habitat of anadromous salmonids. This is acknowledged in the limitations (p. 5-46). Thus, the potential loss and modification of habitat that the report describes could be considered minimal at this time. It would be prudent to confirm the accuracy of the stream layer developed from the 1:63,360 maps in any future analysis.

The potential impact of the mine development and operation on the productive capacity of the various river systems could be developed more fully to gain better insights into potential impacts of the mine. The authors considered the amount of habitat that could potentially be impacted by mine development and operation by estimating the stream length that would be impacted and by considering the percent of spawners of the various species (from ADF&G surveys) observed in potentially impacted areas. However, the productive capacity of given stream reaches for a given fish species can vary widely. Any additional analysis could consider using Intrinsic Potential (IP) (Burnett et al. 2007. Ecological Applications 17:66–80), which considers local geomorphic features to estimate the potential of a given stream reach to provide high quality habitat for a given species. The concept, developed for use in the Pacific Northwest (PNW), has been applied successfully for Chinook salmon in the upper Copper River (A. Bidlack, EcoTrust, Cordova, AK., unpublished). The IP model for Chinook salmon from the PNW that was used in the Copper River was modified after discussion with local biologists. Similar modification may be needed for the PNW IP model for coho salmon to be used in Bristol Bay.

Another factor that I believe merits further consideration is the potential impact of altered thermal regimes of discharge water from treatment facilities (p. 5-28). Warmer water could have potential ecological impacts, particular during the time when eggs are in the gravel. Eggs could develop more quickly and fry could emerge earlier as a result of even minor changes in water temperatures (see: McCullough, D.A. 1999. A review and synthesis of effects of alternations to water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. US Environmental Protection Agency, Seattle, EPA 910-R-99-010. 279 p.; and McCullough, D.A., J.M. Bartholow, H.I. Jager, and 11 co-authors. 2009. Research in thermal biology: burning questions for coldwater stream fishes. Reviews in Fisheries Science 17: 90-113.). These changes could be significant ecologically.

The report noted in several places that the potential impact on groundwater flows was not understood at this time but that disruptions of flow paths could have critical impacts on aquatic resources. One impact that was not mentioned is the loss of over-wintering habitat. K.M. Burnett (U.S.D.A. Forest Service, PNW Research Station, Corvallis, OR., draft report) found that the major overwintering areas for coho salmon in the Nome River, AK were at points of groundwater inputs. The groundwater influx created areas that were less likely to freeze during winter.

Charles Wesley Slaughter, Ph.D.

Yes, the risks to salmonids are well characterized with regard to the hypothetical mine operation itself. However, I suggest that the concept of "no failure," if taken as applying to the entire operation from inception through operation, is not realistic.

The Assessment makes a fair start toward considering the risks to salmonids from the potential transportation corridor. However, the many issues regarding stream and wetlands directly or indirectly affected by roads and pipelines are not fully explored. The extent (length, area) of streams and wetlands affected, as outlined in the text, should be considered a very optimistic lower estimate. The specific issues mentioned, such as bridge or road maintenance, culvert blockage or failure, erosion from cuts, fills, and the roadway itself, are all significant. I simply suggest that the potential consequences of imposition of the (hypothetical) transportation corridor, and future expansions consequent to ancillary infrastructure development and further additional resource extraction projects, would be broader, more severe and of more consequence (and thus should receive more emphasis) than the Assessment indicates. I suggest more fully incorporating Frissell and Shaftel's Appendix G into the body of the Assessment.

John D. Stednick, Ph.D.

To address this question, a water balance needs to be developed for the study area watersheds. Develop a water balance that includes all the principal components and how they may vary in time and space. The site characterization needs significant improvement, particularly as related to hydrologic inventories and processes. Little to no data are presented on temperature, precipitation, evaporation, frozen soils, soil moisture storage, and groundwater storage and movements. The data that are presented often have unreasonable significant figures. The linkage between surface and groundwater needs to be better demonstrated. Hyporheic exchanges are recognized as being important, but the assessment does not demonstrate this linkage.

Iliamna Lake hydrology needs to be characterized. What are the inflows, outflows, and turnover rates? What is the existing water quality in the lake? Aquatic life should be characterized as well. What is the risk of pollutants entering the lake from the road corridor or upstream mine development operations?

Climate variability is recognized as a game changer. What are the potential future scenarios for temperature and precipitation changes in southwest Alaska, and how will these scenarios affect the water balance? How will climate change affect the availability of water for mine operations, including processing and potable uses?

Similarly, a complete water quality characterization is lacking. What is the water quality in surface waters, groundwaters, in time, and in space? What is the definition of background water quality? Numerous exploratory activities have taken place in the watershed and have the potential to affect water resources. How were these separated or addressed? Given the geologic and geomorphologic settings for the study area, are we comfortable that the watershed ridges delineate the watershed area? Groundwater movements may ignore the physical watershed area boundary and follow groundwater gradients. Streamflow measurements from the gauged watersheds could be useful in answering this question. Similarly, the linkage of groundwater and hyporheic exchange needs to be better demonstrated. Do these exchanges occur in all stream segments and gradients? What effect does the groundwater have on stream temperatures? Are depth to groundwater readings available? Is a groundwater monitoring program in place?

The tables and hydrographs (pages 5-32 to 5-39) are unclear. What streamflow changes are associated with what salmon species and life stage? A boundary condition for adults is different than for fry.

The proposed mine will use large quantities of water in ore processing and transport. How much is required and how will this affect water resources; both surface and groundwater? The no-failure mode of operation is predicted to change the watershed contributing area and hence streamflow, and uses the boundary condition of a 20% change in streamflow as significant salmonid habitat loss. The assessment assumes a liner response between watershed area and streamflow contribution, and a linear response between habitat productivity and watershed area. Upland settings are probably more productive in terms of productivity and should be addressed as such. Toxin assessment focused on copper, and other metals can be presented to show the range of metal concentrations for chronic and acute toxicity, i.e., arsenic, molybdenum, silver, barium, and lead. Given the very clean waters (low hardness and organic carbon), the chronic toxicity of various metals should be evaluated. Water quality varies in time and space in the study area, and a better characterization of water quality could be developed. Metal loads could be calculated with streamflow records. What is the proportioning of dissolved versus total metals? Are metals transported with sediments? Do organic carbon fluxes change in space or time?

Specific water quality treatment processes were not identified for the intercepted tailings, groundwater, slurry water, or other mine activity processing waters. The removal of copper from low hardness waters is different than the removal of zinc. A treatability study of all mine drainage waters should be included.

Salmonid risk from travel corridor: The proposed road location has the potential to affect 270 km of stream between stream crossings and Lake Iliamna. The expected road erosion and sediment production has known effects on salmonid resources. The discussion of the travel corridor does not include the potential for road failures, landslides, blocked culverts, or ditch failure. The discussion does not talk about traffic volume or the potential of hazardous material transport on the travel corridor. Need to address road maintenance, fugitive road dust, and road chemicals either dust or ice control.

There is no discussion of water processing after delivery of the slurry to the sea port and return of waters back to the mine site.

Roy A. Stein, Ph.D.

No-Failure Mode of Operation. My comments regarding the no-failure mode of operations and their impact on salmon can be found under Question 3.

Road Use I: Page 5-60. Beyond calcium chloride, how can we be confident that the typical chemicals that derive from highway use will not occur on this mine road (as noted on page 5-60)? Is it because the low volume of traffic? If so, would not we expect accumulation through time…over the 78 years of the mine operation (see Appendix G for some detailed analysis: should some of this material be added to the main report?)? What about the impact of road dust on nearby aquatic systems (wetlands, streams, rivers, etc.)?

Road Use II: Page 5-62 to 5-63 (plus Appendix G: again, as with other appendices, include more of this information in the main report). Will there be frost heave of the road bed such that specific structures will have to be installed to prevent this movement of the road bed? These roads will be treated with chemicals, such as calcium chloride, to keep the dust down and contribute to an ice-free condition, but no data are available for the impacts of these chemicals on nearby streams. How then do we deal with this issue (page 5-62 and 5-63)? The suggestion is that one needs to have roads built at least 8 meters from streams, but this cannot be the case in this situation, simply because of the large number of streams, rivers, and wetlands along the road corridor? More detail as to the impact of the transportation corridor should be added, including issues, such as truck accidents, fuel spills, other chemical spills, etc.

Road Use III: page 5-71 (plus Appendix G). The road will intersect multiple streams and rivers along the northern end of Iliamna Lake, where as many as one third of the sockeye salmon in this lake spawn. And this is where the causeway across Iliamna Lake will be built as well. From my perspective, it seems that impacts on spawning sockeye will be large in this area (without saying anything about causeway: will there be culverts or bridges to allow water and fish to communicate with the rest of the lake)? I would argue this is important, given salmon are attracted to certain odors and water-flows and these odors and water-flows are coming from inlets streams into Iliamna Lake. Preventing any sort of blockage of water flow or salmon migration would be the goal. Are there other issues that should be considered when building this causeway?

Road Use IV. Points made by public testimony reinforces the idea that as this area is opened to the public, the opportunity for new, invasive species to colonize this pristine ecosystem increases dramatically, likely to 100%. Simply put, invasive species will now be carried by humans via the road, inadvertently, into this previously inaccessible watershed.

William A. Stubblefield, Ph.D.

The document appears to adequately address potential questions associated with habitat loss due to hydrologic changes, especially considering the hypothetical nature of the mine and the lack of specific detailed information regarding an actual proposed facility and all of the associated operational details of the facility. The assessment of potential impacts and ecosystem protection parameters is predominately based upon the publication of Richter et al. (2011). Additional support and evaluation of these recommendations for fisheries populations in the Bristol Bay area should be closely evaluated.

Dirk van Zyl, Ph.D., P.E.

Chapter 5 of the EPA Assessment is entitled: "Risk Assessment: No Failure". Chapter 5 presents an evaluation of habitat loss and modification resulting from the hypothetical mine. A summary of the "risks" associate with the "no failure" case is provided in Chapter 8. There is specific focus on evaluating the magnitudes of the losses and modifications to the environment.

A risk assessment addresses three questions (Kaplan and Garrick, 1981):

- What can happen? (i.e., What can go wrong?)
- How likely is it that that will happen?
- If it does happen, what are the consequences?

There are a large number of risk assessment methods and it is common to express the magnitude of risk as a combination of likelihood of occurrence and consequences (IEC, 2009). This is the typical outcome for engineering assessments of systems. For example, in the case of a Failure Mode and Effects Analysis (FMEA), it would be typical to develop a risk matrix to combine likelihood of occurrence and consequences to express the level or magnitude of risk in qualitative terms (Robertson and Shaw, 2012).

The EPA Assessment describes the two components of risk but does not provide any information on the magnitude of the risk. For example, for the no-failure condition it describes the length of streams, areas of wetlands, etc. that will be impacted by developing the mine, i.e. the consequences. One may argue that the likelihood of occurrence of these consequences is unity (or certainty) if the mine is developed, as this is not specifically addressed by the report. One would next expect an expression of the magnitude of this risk based on some comparison of the consequences to a set of outcomes that could result in acceptable or unacceptable risks. The EPA suggests this as an approach in its 1998 Guidelines for Ecological Risk Assessment (EPA, 1998): "In some cases, professional judgment or other qualitative evaluation techniques may be used to rank risks using categories, such as low, medium, and high, or yes and no". Quantitative approaches such as fuzzy logic has also been used to develop expressions of magnitude of risk as described by EPA (1998): "For example, Harris et al. (1994) evaluated risk reduction opportunities in Green Bay (Lake Michigan), Wisconsin, employing an expert panel to compare the relative risk of several stressors against their potential effects. Mathematical analysis based on fuzzy set theory was used to rank the risk from each stressor from a number of perspectives, including degree of immediate risk, duration of impacts, and prevention and remediation management. The results served to rank potential environmental risks from stressors based on best professional judgment".

It is unclear to the reader how significant a loss of 87.5 km of streams in the Nushagak River and Kvichak River watersheds is to the overall ecosystem. Are there any criteria that can be used to develop such an expression? Can a multi-stakeholder workshop (as is often done) be used to develop such criteria and expressions of risk magnitude? Without having such expressions of risk magnitude it is impossible for those without specific expertise in salmonids to evaluate whether this is a significant risk. Price et al. (2010) states that: "Between 1999 and 2008, 3,500 fish passage barrier culverts were replaced with fish-passable structures, reportedly opening nearly 5,955 km of fish habitat in Washington streams (Governor's Salmon Recovery Office 2008)". Comparing the loss of 85 km to this gain of 5,955 km seems to imply that 85 km loss may represent a relatively small risk, which may not be the case at all. However, the EPA Assessment does not provide any insight in the magnitude of risk except to provide a value for the consequences.

Similar comments can be made with respect to the relative risks associated with the other losses of ecological functions for other failure modes.

It is recognized that it is important to maintain separation between the risk assessment and risk management functions. As expressed by the National Research Council Panel in their report on Science and Decisions (NRC, 2009): "The committee is mindful of concerns about political interference in the process, and the framework maintains the conceptual distinction between risk assessment and risk management articulated in the Red Book[2]. It is imperative that risk assessments used to evaluate risk-management options not be inappropriately influenced by the preferences of risk managers".

Providing an expression of risk magnitude should not interfere at all in the separation of risk assessment and risk management, but should provide the risk manager with one extra level of analysis and insight from the expert assessor of the problem at hand. Multi-stakeholder interaction will only serve to enhance the value of the risk ranking.

On p. 4-33, it is stated that after closure: "No PAG waste rock would remain on the surface". It is also stated in Chapter 4 that PAG and NAG waste will be segregated. On p. 5-48, it is stated that: "However, the primary concern during routine operation would be waste rock leachate. That leachate would become more voluminous as the waste rock piles and uses of waste rock for construction increased during operation. After mine closure, it would be a major source of routinely generated wastewater along with water pumped from the TSF and pit. Leachate composition from tests of the three waste rock types (Tertiary, East Pre-Tertiary, West Pre-Tertiary) is presented in Tables 5-14 through 5-16". There is no specific indication which of these waste rock types could be described as PAG or NAG and Chapter 5 seems to assume that these 3 samples are representative of the total amount of waste rock, about 4 billion tonnes for one mine scenario. If all the PAG material will be removed from the surface, as stated in the scenario in Chapter 4, and the NAG will not generate acid drainage, then it is difficult to understand why the waste rock piles and waste rock used for construction (supposedly all NAG at this stage) would be the major source of "routinely generated wastewater."

[2] The so-called "Red Book" refers to: National Research Council (NRC). 1983. Risk Assessment in the Federal Government: Managing the Process, Washington, DC: National Academy Press.

Note that it is further unclear why there would be water pumped from the tailings and the pit if the TSF were closed, as discussed above, and if it will take the mine pit 100 to 300 years to fill. Some clarification is in order.

A further reference to the fate of waste rock after closure is found on p. 5-77 of the EPA Assessment: "Under the mine scenario, the mine pit, waste rock piles, and TSF would remain on the landscape in perpetuity and thus represents permanent habitat loss." It should be noted that the scenario states that PAG will not remain on the surface, whatever volume and area of land surface that represents.

The descriptions of exposure and exposure-response resulting from the transportation corridor in Section 5-4 of the EPA Assessment focus on potential impacts and make use of references that are clearly not representative of the expected road construction. A number of these references date from 1975 and 1976 (p. 5-59) and are not necessarily representative of road design and construction practices in 2012. On p. 5-62, the following statement and reference is given: "Sediment loading from roads can severely affect streams below the right-of-way (Furniss et al., 1991 and references therein)". This reference is specifically focused on forest and rangeland roads, clearly not representative of a major transportation road between a mine and the port facilities from where its products are shipped. This publication contains many recommendations specifically for forest and rangeland roads and some of them are indicative that it is not applicable to the transportation corridor for a major mine access road: "Design cut slopes to be as steep as practical. Some sloughing and bank failure is usually an acceptable trade-off for the reduced initial excavation required" (p. 306); and "stream crossings can be considered dams that are designed to fail. The risk of failure is substantial for most crossings, so *how* they fail is of critical importance" (p. 310). The reference also refers to the application of oil as a dust abatement additive on p. 312, which is hardly acceptable practice. In my review, I did not find that any of the references used in the EPA Assessment refer specifically to mine roads such as those considered for the transportation corridor at the Pebble Mine scenario.

It is further interesting that it is stated on p. 5-60 that there will be 20 bridges and 14 culverts along the road without referring to this as an assumption, and no reference is cited for this information. Will there be a change in impact if the decision is made to build 30 bridges and 4 culverts or 34 bridges and no culverts?

The discussion on the potential impacts of the transportation corridor on salmonids serves the purpose of highlighting some aspects that engineers and fish biologists must take into account when designing and maintaining the final transportation corridor for the Pebble Mine and other mines in the Bristol Bay area. However, this assessment does not appropriately describe the scale and extent of the risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation.

Phyllis K. Weber Scannell, Ph.D.

The no-failure model makes a number of assumptions about how the mine will be developed – some may be accurate, some may be considerably different. It is important to take under consideration that Pebble is currently a prospect, not a mine. Should this project proceed to mine development, it will be incumbent on the mining company to develop a rigorous mine plan that includes detailed information on all aspects of a future project. This mine plan will be reviewed by state and federal staff with experience in large project development.

The no-failure model discusses the amount of riverine habitat that will be lost to mining by the mine pit, tailing storage facility, and waste rock dumps. Anadromous fish habitat is protected under Alaska Statute 16.05.840-870. The statute requires review of a project potentially affecting fish habitat and, where necessary, avoidance, mitigation, or compensation. A project must provide free passage of fish; the project cannot be placed in such a way that fish are prohibited from moving into the upstream reaches. Estimates of habitat loss from the mine footprint are not possible without a more detailed plan of operations for the mine.

There are many aspects of the development of a large mine project that need thorough review to ensure that habitats are protected. These include, but are not limited to: classification and storage of waste rock, lower grade ore, overburden, and high grade ore; development and maintenance of tailings storage facilities; development and concurrent reclamation of disturbed areas, including stripped areas and mine pits; collection and treatment of point and non-point source water; quantity and timing of discharges of treated water; monitoring of ground water, seepage water and surface water; and biomonitoring. The transportation corridor will require review and permitting of every stream crossing of fish-bearing waters. In addition, plans should be developed for truck wheel-washing to minimize transport of contaminated materials.

Paul Whitney, Ph.D.

<u>Material Resource Areas.</u> Material resource areas, mentioned on page 4-34, for the road and pipelines should be discussed in more detail. Will aggregate be required? If so, where are the aggregate resources in relation to floodplains? I spent a summer surveying material resource areas for a proposed arctic and subarctic pipeline and access road. Suitable material resource areas are sizeable and are often important (e.g., aggregate) for wildlife (such as bears that hibernate or survive the winter in dens) and fishery resources. Sometimes dens can only be excavated in non-permafrost (i.e., aggregate) soils. It appears the project area is in a zone of discontinuous permafrost, but permafrost could be more continuous in the higher elevations along the road through the Kenai Mountains. An accurate assessment should determine the permafrost location(s), as well as the area and importance of material resources for fish and wildlife. In addition, Reclamation Plans for the material resource areas should be briefly discussed to ensure that areas mined for aggregate will not avulse and capture streams.

<u>Water for Dust Control.</u> Dust control for the 86-mile proposed haul road will likely require a lot of water. Where will this water come from? Withdrawal from streams crossed by the haul road could have impingement and flow reduction consequences. Adequate screening could solve the impingement issue. Some back-of-the-envelope calculations could determine if water withdrawals for dust control could alter the projected hydrographs when salmonids are present in the streams.

Question 5. Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?

David A. Atkins, M.S.

The Assessment focuses on some low probability, high impact failures (e.g., TSF failure), and presents summaries of failures at existing mines. The majority of the focus is on catastrophic failures, such as TSF, pipeline, water collection and treatment, and road and culvert. Anecdotal information regarding mine failures is numerous, but often not well documented, so it is difficult to get information on the details of failures of other projects. It is also difficult to extrapolate the probability of failure from one site to the next, and the report stresses the wide range of uncertainty, depending on design and environment. Without a more detailed understanding of the mine plan and associated engineering, as well as additional detailed analysis, it is difficult to determine if the failure probability estimates presented in the Assessment are reasonable.

The focus on catastrophic failures also takes attention away from what is probably a more likely scenario. Every project is subject to accidents and smaller, non-catastrophic failures that have varying degrees of consequence. Sometimes these failures are easily identified and fixed and other times they can go un-noticed for periods of time.

It would be helpful to describe some smaller-scale failures that have occurred at mine sites. A partial list includes: accidents and spills along the transportation corridor or within the mine site; unanticipated seepage of contaminated water that may be difficult to detect, collect and treat; movement of water along preferential flow pathways that are difficult to characterize; temporary failure of water collection and treatment systems; mistakes in engineering analysis that underestimate the volume of water that must be collected and treated or overestimate the volume of water available for use; and designing based on incomplete data and understanding of climate conditions.

Steve Buckley, M.S., CPG

The engineering failures reasonably represent potential system failures outlined in the mine scenario based on historic porphyry copper deposits of this type. It is less clear if the failures reasonably represent a mine scenario based on state of the art engineering and mitigation practices. Appendix I provides some information related to potential system failures and possible mitigation measures designed to minimize these risks but these are not treated in any detail in the assessment. It would be difficult to pull together the most modern engineering and mitigation practices from around the world but it could help bound the risks associated with modern mine development.

The Red Dog mine in northwest Alaska might be relevant for estimating potential mining activities in the watershed. Although the characteristics of the deposit differ significantly, at roughly 150 million tons, it is half the size of a reasonable minimum mine scenario and would be helpful to characterize some minimum mine development scenario.

Courtney Carothers, Ph.D.

The potential failures outlined in this assessment include: tailings dam failures, pipeline failures, water collection and treatment failures, and road and culvert failures. These failures appear to represent the key potential failures for this mining scenario, their risks appear to be estimated reasonably, and statistics from existing mines appear to be used appropriately, although I have no particular expertise with which to evaluate this assessment. As we discussed in our peer review panel, the focus here is on catastrophic failure. More detail should be provided on likely non-catastrophic failures, ones that would be more difficult to detect.

Dennis D. Dauble, Ph.D.

My experience in system failure of mines of the size and type outlined in the scenario is limited. However, what does seem to be missing is the long-term effects of leachates to receiving water bodies in any type of risk scenario, including both non-failure and failure modes. That is, assuming no catastrophic failure, how might tailings constituents interact with aquatic habitats seasonally, such as during periods of snowmelt and severe rainfall events?

Gordon H. Reeves, Ph.D.

This is an area outside my expertise and I am unable to evaluate and assess the adequacy of what was presented.

Charles Wesley Slaughter, Ph.D.

Potential failures seem reasonable, based on history of other mining operations. However, the consequences of hydrologic extremes during winter (frozen soil) conditions are not adequately addressed. The possibility of the mining operation and the transportation network encountering discontinuous permafrost is not mentioned, although at least some soils maps indicate permafrost presence.

The probability approach outlined for potential TSF dam failure is unpersuasive. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication on p. 4-47 that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult to interpret, given the lack of historical seismic records for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. (The suggested 200-year return period should also be viewed in light of the 79-year suggested operating life of the hypothetical Pebble operation, probable longer-time operations at other mineral extraction sites which would be developed following implementation of Pebble and building from the infrastructure associated with Pebble, and also the projected very long persistence of the TSFs following cessation of active mining).

Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."

John D. Stednick, Ph.D.

The assessment reasonably addresses potential large system failures, but should include a variety of smaller and perhaps more frequent failures (see Question 4). A large tailings storage facility failure compared to a blocked road drainage culvert. The level of detail in the assessment of the potential system failures varies considerably and baits the question--why? Does this demonstrate lack of understanding of failure prediction, lack of failure prediction, or writing team expertise?

Tailings storage facility: The liquefaction phenomenon, internal and external erosion, seepage, and overtopping are some of the main failure modes of tailings storage facilities. A large quantity of stored water is the primary factor contributing to most tailings storage failures. The risk of physical instability for a conventional tailings facility can be reduced by having good drainage and little (if any) ponded water. Some suggest that the tailing pond freeboard should be able to accommodate the 100-year, 72-hour storm/streamflow event. What are the State of Alaska standards? Discuss the probability of failure of a TSF from other than overtopping by a precipitation/streamflow event. The potential of seismic activity and its effect on tailings storage and other earthworks needs to be addressed.

Chemical transport spill: Mine development and ore processing will require significant loads of petroleum and chemical products. Although the exact processing formulations are not given, most copper porphyry mines use similar formulation in ore flotation and processing. How will chemicals be stored, transported, and recycled? What are the opportunities for accidents to occur?

Roy A. Stein, Ph.D.

Failures Appropriate for Mines of this Size and Type. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein. Some of the public testimony spoke directly to comparisons with existing mines in dry areas would be completely inappropriate because it is the hydrology of the Bristol Bay watershed that would make it so very vulnerable to mining impacts.

Failures Not Described? I speak to failures associated with routine operations previously in this review, as well as chemical spills along the transportation corridor. Also included herein should be impacts of the Cook Inlet Port and potential spills, accidents, etc., on the marine ecosystem.

Probabilities and Risks of Failures. These seemed reasonably well documented, though again this falls outside of my expertise. Even though out of my realm, I still would have liked a more quantitative assessment of these risks, developed in a rigorous, defensible way. I am discouraged when I understand that history (in the eyes of the mining company) is not a good predictor of the future because technology has taken us so much farther along, reducing risks of whatever failure significantly. In my view, this is a specious argument and one that should be roundly put to bed by the authors of this report. History is indeed the absolute best predictor of the future and technological changes that have occurred since past mines must be absolutely and critically evaluated to determine if indeed risks do go down. This is a serious issue and one that should be addressed with some rigor by the authors.

Existing Mines as Comparisons. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein (nor does it incorporate all we have learned in the mining business since the last mine for which we have data). Even so, I again caution the authors that these existing, historical mines provide the best data we have to estimate risks of failure and that, under no circumstances, should one accept the indefensible argument that progress with mine safety (speaking broadly, not just human health) has progressed to the point that these risks, previously quantified in these older mines, are now small. As suggested above, we have no other quantitative values for risk, except for existing mines and we cannot simply erroneously lower the risk based on new, **untested** technologies.

Proportional Losses of Salmon. Is it possible to estimate the proportion of the salmon runs compromised in the face of major failures in tailing storage facilities or other failures? In other words, I would recommend adding a chapter that uses best estimates of salmon produced within the Bristol Bay watershed and then assess the maximum impact of, let's say, a Tailing Storage Facility failure---with this failure, might we lose 10%, 40%, or 75% of our salmon productivity? In addition to this estimate, one might estimate the number of stocks or unique genetic units lost with a major failure? I know these numbers are difficult to get, but if one begins with escapement from these systems as well as insights from harvest, we may be able to bound these impacts. Only in this fashion can we put these data into context. This exercise also will serve to counter the argument by the mining company that they are only destroying some small percentage of salmon habitat and hence (assuming a linear relationship between habitat lost and salmon eliminated) only some very small percentage of salmon. Because losing 2% of critical headwaters habitat may translate to huge losses of salmon (say 20%), one simply cannot assume a linear relationship between habitat and salmon. Explicitly making this argument improves the rigor of the main report.

Correlations between Ocean and Terrestrial Conditions. From the literature (see Irwin and Fukuwaka. 2011. ICES *J. Mar. Sci*. 68: 1122 as just one example), we know what climatic conditions lead to poor rearing conditions in the ocean, thus compromising growth and ultimately survival of salmon. Given these ocean conditions, might we have correlative effects in the terrestrial environment, thus leading to a cumulative effect of ocean and terrestrial impacts? For example, if particular oceanic conditions underlie poor survival, might this correlate with an increased probability of flooding, leading to a higher probability of a Tailings Storage Facility failure, leading to a cumulative synergistic effect that could be multiplicative in its negative impact on salmon populations? Was there any attempt to correlate these impacts? Just how realistic is it to reflect on these sorts of multiplicative effects? Might these effects have a catastrophic effect on salmon populations?

William A. Stubblefield, Ph.D.

The scope of failures described in the assessment seems to be sufficiently comprehensive and all likely failure-types are considered. The probabilities and risks for failure seem to be adequately estimated, given the state-of-the-science; however, these estimates are likely to be very sensitive to site-specific concerns and operational considerations. Once site-specific information is available, it is likely that much better estimates of failure potential at a site can be developed.

Dirk van Zyl, Ph.D., P.E.

Failure modes outlined in the EPA Assessment do not reasonably represent the potential failures that could occur at a mine of the type and size outlined in the mine scenario.

The EPA Assessment considers a series of large, or catastrophic, type failures. The failure modes considered in the mine scenario include four major items: tailings management facility;

pipelines; water collection and treatment; and, road and culvert. These failure modes are included in the risk assessments for a mine of this type and size, either qualitatively as is typically done in FMEA, or quantitatively. However, the range of failure modes will also consider many other types of failures that can also occur during regular mine operations. These other types of failures may result in the full spectrum of risks (from insignificant to very high) depending on site and mine life-cycle conditions. Performing extensive analyses for the four major items implies that they could occur and that they are the only failure modes that will be significant.

The risks of failures in the EPA Assessment are not estimated appropriately, as their magnitudes are not estimated at all. The likelihoods of failure and their consequences are estimated in Chapter 6. However, there is not a complete risk analysis. Refer to discussion in Question 4 above.

Responses to the other parts of the current question (Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?) are further discussed in my responses to other questions below.

Phyllis K. Weber Scannell, Ph.D.

This section focuses on catastrophic failures; however, there are a number of non-catastrophic failures that can occur at a mine site. Non-catastrophic failures include leakage of contaminated water to ground or surface waters from PAG waste rock, the tailing storage facility, and exposed ore surfaces, and from emergency discharge of untreated water from the TSF and ore spills from trucking accidents. Such failures can be minimized or prevented with good site planning and monitoring. An additional "failure" has been experienced at a mine in Alaska when the water elevation of the tailing pond was sufficiently high to cause groundwater flow across a natural divide into an opposite drainage.

Paul Whitney, Ph.D.

Sediment Transport. The failure analysis indicates a sediment transport study was beyond the scope of the assessment. Not only is such a study important for fish resources, it is important for all ecological resources, especially plant community succession along the stream and a delta into Bristol Bay.

This might seem extreme, but the failure analysis indicates the Koktuli, Mulchatna, and Nushagak Rivers would stabilize into a new channel after a failure and not continue to work their way across the floodplain and eventually transport materials hundreds of miles down river. The Mount St. Helens eruption, given as an analogy in the assessment (page 6-3), certainly moved sediment into the Columbia River Channel, the Columbia River Estuary, and Pacific Ocean over a hundred miles away. Copper concentrations in the Columbia River estuary as a result of the eruption ranged from 1 to 43 µg/L (Lee 1996). The upper limit of the range is approximately 20 times greater than the no-effect benchmark listed in the assessment. The down stream consequences of changes in sediment transport and water/sediment chemistry for fish and wildlife are sometimes very large, not anticipated (see Peace Athabasca Delta response below), and costly to remediate. Solutions for the Peace Athabasca Delta involving check dam construction may not be directly applicable to a tailings dam failure analysis in the assessment but may have some value short of dredging. I'm not sure how it would work, but a mitigation effort (page 4-32, para 3, last sentence) using bulk tailings would apparently be placed down gradient to catch tailings in the event of a failure. Is this a safety check dam? It is possible that the assessment could be improved if this and other redundant efforts to minimize risk could be discussed in more detail and considered in the failure analysis.

I agree with the assessment's statement on page 6-11 (6 lines down) that impacts of a tailings dam failure to fish would extend down the mainstem Koktuli River and possibly further. If the Mount St. Helens analogy is a good one, the impacts could reach Bristol Bay. Even if the Mount St Helens analogy is not a good one, I suspect sediments would continue to move down river as the river(s) moved across their floodplains through time. I also agree with the assessment's statement that the time to reach dilution approaching background would be very long, as the sediments in tributary rivers to Bristol Bay will be continually reworked (page 6-25) and resuspended.

As a terrestrial ecologist, I have always been impressed by the impact of Bennett Dam on sediment transport in the Peace Athabasca Delta ecosystem over 600 miles away (Cordes 1975). The assessment does mention the potential impact of toxics on the likelihood of plant community succession on deposited tailings (page 6-10), but this causal pathway was not assessed. Given the increases in metal concentrations in the Columbia River Estuary cited by Lee (1996) for the Mount St. Helens eruption, an assessment of down stream sedimentation and changes in sediment chemistry should be addressed. The likelihood that far reaching impacts of a failure could influence plant succession and wildlife habitat quality is probably not anticipated but given the Mount St. Helens analogy and the lessons learned from Bennett Dam, the likelihood of such impacts deserve more attention.

<u>Sediment Benchmarks.</u> Once again, as a terrestrial ecologist with ecological risk assessment experience, I know that sediment chemistry and determining toxic benchmarks for sediments is very complex and subject to varied opinions. I admire the MacDonald et al. (2000) effort to reach consensus on sediment benchmarks but I have three concerns. First, the consensus values listed in MacDonald et al. (2000) are geometric means of values from several sources. The mean consensus values likely do not equate to No Observed Effect Concentrations, which would probably be lower than the mean values. Second, the lack of observed effects was sometimes for a "majority" of sediment dwelling organisms, but not all (MacDonald et al. 2000, Table 1). Third, some of the sources used for the mean values included interstitial water, but apparently not all (Table 1). I will always remember Dr. John Stein (currently the acting director of NOAA's Northwest Fisheries Science Center in Seattle) standing up at a workshop for the Columbia River Channel Deepening Project. He had a small bottle of sediment and water in his hand and, while shaking it, he said something to this effect: It's the pore water we are interested in. Considering that a proposed mine, at some point, will be reviewed by NOAA, it seems appropriate to consult with NOAA regarding benchmarks for <u>all</u> the species of sediment/pore water-dwelling organisms likely to occur in the potentially effected watersheds addressed in the assessment.

Question 6. Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

Water treatment failures of varying scale occur at virtually every site that treats water, and mine sites are no exception. The risk of failure of water treatment described in the assessment is useful as background, but as the report states, the risk is highly uncertain. A non-catastrophic water treatment system failure is fairly likely to occur at some point during the mine life, and, hence, requires a detailed assessment. The treatment in the Assessment is cursory (less than one page). This type of failure is much more likely than a TSF failure (which receives more than 20 pages of analysis), and therefore requires a much more thorough treatment given the probability of occurrence and likelihood of impact to salmon species.

The background water chemistry indicates mineral concentrations are very low. Therefore, water treatment will be challenging if background conditions are to be met. Treatment will be especially challenging given the sensitivity of the species of concern to concentrations of copper, for instance, as well as the sensitivity to temperature that may be difficult to match in a water treatment system.

During mine operation, a lapse in treatment would likely be identified and addressed quickly. This type of treatment failure is ephemeral and would likely have a short-term impact on the fishery, depending on the time of year of occurrence. It is likely that any impacts to the fishery could recover in subsequent years after the problem is fixed. The site will require water treatment long after closure, possibly in perpetuity. This period is more problematic, as a water treatment failure could go unnoticed for some time or the resources may not be available to correct it quickly, depending on how long after closure the failure occurs and the stewardship of the treatment system.

Steve Buckley, M.S., CPG

Less than a page (4-39) is devoted to the failure of water and leachate collection and treatment. This seems inadequate given it would be one of the main systems that could impact fish at the potential mine site. In contrast, 20 pages are devoted to tailings dam failure (p.4-39 to 4-60).

Courtney Carothers, Ph.D.

The report concludes that wastewater and leachate treatment and collection failures could expose local streams to mildly to highly toxic water harmful to invertebrates and fish species. Depending on the type of failures, these exposures could last from a period of hours to years. The report notes that in the case of Red Dog Mine, Alaska, the water treatment system was inadequately designed, but does not discuss why such a design was approved and allowed to be implemented, nor does it discuss the likelihood of replicating such a design flaw in future mining scenarios.

Dennis D. Dauble, Ph.D.

More information on local hydrology, including seasonal runoff patterns (e.g., peak flows) and groundwater movement would be useful. I found no description of existing water quality characteristics of potential receiving waters, except what is included in Table 5-17 of the main report. Are these values (such as hardness, which moderates metal toxicity) consistent throughout the watersheds, including downstream lakes? Other questions include: What volumes of leachates might be collected and treated versus volumes not captured and subsequently released downstream? Is copper the only constituent of concern to aquatic animals? Are there processing chemicals that would also be toxic?

The assessment should also consider and discuss relative risk to aquatic ecosystems from downstream transport of sediment-bound metals to Iliamna Lake, if deemed probable.

Gordon H. Reeves, Ph.D.

The primary impacts are from the toxic effects of the water and leachate on fish and aquatic invertebrates. This is outside my field of expertise so I am unable to assess the appropriateness the risk characterizations or to provide insights about additional literature.

The report focused primarily on the lethal effects of the contamination from leachate and water treatment and collection failures. However, could there be ecological consequences to fish and invertebrates that are not directly lethal but that could have ecological consequences over the long term? I suggest that this needs to be considered more fully in this assessment.

Sockeye salmon are most abundant salmon in Bristol Bay and a primary species of focus in this analysis. The direct impacts of mine and mine-related activities have been considered but there appears to be a lack of consideration of the impact on zooplankton, the food source for sockeye. If this were a deliberate omission, then a statement about why it was omitted is required. The revision should include this if it was an oversight.

Charles Wesley Slaughter, Ph.D.

No. Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams…" – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).

John D. Stednick, Ph.D.

The TSF is designed to hold the tailings under water to minimize the oxidation of pyritic materials and limit ARD or AMD production. The TSF will be underlain by hypalon to capture leakage waters. There is the possibility of failure to collect waters from the TSF—either surface runoff or leakage with or without storm (precipitation) events. There is also the possibility of failure of the treatment plant to treat the wastewater. Such treatment systems in Colorado usually have a bypass pond to temporarily hold waters for later pump back and treatment as a result of power failure, plant going off-line, storm events, or plant maintenance.

The waters in the study area have very low buffering capacity; metal toxicity would occur at low concentrations and dilution of metals would require time and space. The maximum index counts on page 6-39 are confusing and not well related to the risk characterization. Copper was used as an example metal, but other metals are also toxic and further characterization of the waste rock can be presented. Further analysis of a water and leachate collection failure can be made over time: the effects of dilution flows over the various months with low flows, or when adult salmon are present in the stream as opposed to juveniles – or, when juveniles are emerging. The toxicity quantification is difficult and appears more of an academic exercise here, rather than site specific.

Leachate collection from the tailings area is only briefly described. What are the State of Alaska standards for collection and treatment? What are the potential effects of not collecting or treating the tailings leachate waters? Compare the detail and length of leachate discussion to the TSF failure discussion (see earlier comments).

Given the hydrologic connection between surface and groundwaters, what effect will interception of all waters on the TSF do to the surrounding wetlands and groundwater levels? Again the lack of a water balance does not let the reader determine if this water interception is significant or will have significant resource effects.

Most, if not all of these failures are the result of human error. What safeguards will be in place? What are the best mining practices to minimize human error?

Roy A. Stein, Ph.D.

Groundwater Connectivity and TSF Construction I. Extensive connectivity between surface water and groundwater means that any failure will allow contaminated waters to flow quickly to areas of importance for salmon. And, indeed how does one build a tailings pond (coarse textured glacial drift in the Pebble Mine area) with this much permeability? Why would one only line the tailings dam; shouldn't the entire Tailings Storage Facility be lined? Would not this be "Best Practice"?

Groundwater Connectivity and TSF Construction II: A water-impermeable barrier will be installed only on the interior dam face and nowhere else. To prevent communication between these facilities and the groundwater, is it feasible to map groundwater inputs before the facility is filled, place barriers over these areas, and thereby reduce influx of groundwater into the facility and perhaps prevent movement of toxic water into the groundwater? I make this point with some hesitation, given the point made on page 5-29:

> "Projecting specific mining-associated changes to groundwater and surface water interactions in the mine area is not feasible at this time."

Failure of Leachate and Water Collections. See my comments under Question 12 below. In addition, I see this as a huge undertaking for which monitoring and response (mitigation) are clearly as important as the actual plan to capture these wastes.

William A. Stubblefield, Ph.D.

The risk assessment attempts to consider the effects of metal discharges for water and leachate from the mine site. This assessment is based on metals concentrations measured in potentially "similar" mine waters from other sites; concentrations of metals are likely to differ based on source material and operational differences. The effects concentrations used in the evaluation are based on US EPA ambient water quality criteria (AWQC) for metals, and this approach is appropriate for "screening level" evaluations. It should be noted that exceedence of an AWQC does not portend the occurrence of adverse effects. Ambient water quality criteria are derived in such a way that they are intended to represent "safe concentrations." In other words, if environmental concentrations remain below the AWQC, it is assumed that unacceptable adverse effects will not occur; exceedence of an AWQC suggests that adverse effects may occur to some species, but that this must be evaluated more closely. Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD); therefore, direct effects on salmon are even less likely at concentrations in the range of the AWQC.

It is interesting to note that the risk assessment document states that copper is one of the "best-supported criteria. However, it is always possible that it would not be protective in particular cases due to unstudied conditions or responses." Further, the document goes on to suggest that organisms such as mayflies etc. are important to the aquatic ecosystem but are not considered in the copper AWQC and therefore may not be sufficiently protective. It also suggests that because an acute-chronic ratio approach is employed to correct the final acute value to obtain a final chronic value, there may be increased uncertainty associated with the protectiveness of the chronic criterion. This appears to be an area where EPA might benefit by conducting research (either alone or in concert with industry) to reduce uncertainty in the criteria to an acceptable level. In addition, additional chronic toxicity data may be available from research conducted in response to the European REACH regulations and consideration of this research may reduce the level of uncertainty in the criteria. Bioavailability correction via the BLM approach is only considered for copper in the risk assessment; biotic ligand models have been developed for a number of metals (e.g., zinc, nickel) and these should be considered in the assessment as well. Finally, the assessment approach seems to use a sum TU-based approach for assessing "metals mixture" impacts. This is based on an assumption of additive interactions among the metals. Although this is probably the best assumption in going forward, limited data are available to support this approach.

Areas where additional research would be beneficial include:

- Mixtures: Information regarding the potential interactive effects of multiple metal exposures would be useful and would reduce assessment uncertainty.
- Species sensitivity concerns: there is extremely limited data (esp. chronic datat) on all of the salmon species of concern in Bristol Bay
- Additional data, especially chronic toxicity data and data for additional metals for which no water quality criteria exists, would be extremely helpful.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential failure of water and leachate collection and treatment from the mine site.

Water collection and treatment failure likelihood. An estimate is presented for the amount of seepage that may flow from the TSF. Similar estimates are not presented for the waste rock piles. The effects of the effective exclusion of oxygen from the saturated or partially saturated tailings should be considered in developing an estimate of the water quality of the resulting seepage. It may be an important factor in reducing the oxidation of sulfide minerals remaining in the interior of the TSF. This same effect could also mitigate the release of poor water quality in the long-term following closure. The precipitation on the site may be sufficient to effectively retain a suction saturated profile in parts of the TSF.

Water collection and treatment failure consequences. Water collection and treatment is being done at a number of mines in North America. Past experience at the Red Dog mine is quoted; however, there are many other examples that could have been examined. An important example is that of the Equity Silver Mine in British Columbia (Aziz and Meints, 2012): "Acid Rock Drainage (ARD) was discovered at the Equity Silver Mine in the interior of British Columbia in 1981. The latest water treatment plant was installed in 2003, 9 years after the mine closed in 1994, and is the fourth successive treatment plant for the site that has treated ARD for a period of over 30 years. Discharge water quality was maintained since 1991 except during two high flows associated with freshet conditions in 1997 and 2002. ARD collection and treatment system upgrades were installed after 2002 and these have performed well through three large freshet conditions in 2007, 2011 and 2012. The timeframe for treatment is perpetuity and financial assurance is in place for a total amount of $56.291 million through a long-term security bond (letter of credit) with the BC Provincial Regulatory Authority. The security bond is reviewed by stakeholders every 5 year". Collection and treatment at Equity Silver indicates that companies are committing to long-term water treatment of ARD and that regulatory frameworks are in place to protect water quality in downstream streams and rivers. It is recommended that EPA perform a more thorough review of other sites where water treatment occurs to better characterize this failure mode.

Phyllis K. Weber Scannell, Ph.D.

This section of the report provides an in-depth discussion of possible sources and fates of contaminated water. Chapter 6.3 discusses possible adverse effects from early mine closure or prematurely shutting down a water treatment system. These issues highlight the need for a mine plan that includes concurrent reclamation, sufficient bonding to conduct reclamation in the event of an early shut down, and plans and specifications for collection and bypass of clean water and collection and diversion to a water treatment system of contaminated water.

The Risk Characterization (Section 6.3.3) discusses possible contaminant loads to downstream waters. As stated in this section, it "serves to indicate the large potential risk from improperly managed waste rock leachate." This statement highlights the need for an in-depth mine plan with sufficient monitoring and fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized.

Section 6.3.3 (Risk Characterization) states "Alternatively, water collection and treatment failure could be a result of an inadequately designed water treatment system which could result in the release of inadequately treated water as at the Red Dog Mine, Alaska (Ott and Scannell 1994, USEPA 1998, 2008). In that case, the failure could continue for years until a new or upgraded treatment system is designed and constructed." This statement is misleading and overly simplistic; the water treatment system at the Red Dog Mine was designed to treat the predicted flows. However, the stream bypass and collection systems were constructed in 1991 to intercept seepage waters. The additional water that was collected and treated dictated construction of a second water treatment system in 1992. Sand filters were added in 1993 to remove fine particulate Zn. The issue was not that the water treatment was inadequate, but that the pre-mining hydrologic data was insufficient and that state, federal, and mine officials lacked experience in mine construction on permafrost soils.

Overall, the discussions of risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site highlight the need for more comprehensive information on groundwater, including delineating flow pathways, depth to surface, and water volumes. Additional information is needed on water collection, storage, and treatment at future mine facilities.

Paul Whitney, Ph.D.

No comment.

Question 7. Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The description of culvert failure is necessarily general because there are currently no designs. The general data on culvert failures presented for the types of culverts described in the references cited (principally for forest and range land) indicate a high probability of failure (30-66% failure rate). It is probable, however, that the transportation corridor for the project would be constructed to a higher standard than most of the roads included in these papers. It would be helpful to know if similar data are available for highly engineered roads of the type likely to be built for the project.

Steve Buckley, M.S., CPG

The references provided in this section emphasize culvert failures in the Pacific Northwest and Tongass National Forest. The streams and culverts in these regions are heavily influenced by large woody debris loading. It would be more appropriate to classify the various potential stream crossings by watershed and the amount of large woody debris available to be recruited to the stream and influence culvert blockage.

Courtney Carothers, Ph.D.

Culvert failures due to blockage and erosion are noted to be common and are likely to occur in this scenario. Culvert failures would prevent the movement of fish, which could eliminate a year class from blocked stream systems and fragment upstream and downstream populations, increasing likelihood of localized population depletions and extinctions. Monitoring and maintenance of culverts can be expected to decrease after mine operation, increasing the risks of these failures. The report appears to appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

Mitigation practices, such as new culvert design, was well described, as was bridging of roadways and porous fills to mitigate risks due to culvert failure along the transportation corridor. This assessment also included appropriate risk characterization for both the no-failure and failure scenarios. There should be literature available from the Washington State Department of Transportation on fish passage relative to culvert placement and design. Otherwise, I have no suggestions for improvement.

Gordon H. Reeves, Ph.D.

The literature review of culverts and their potential impacts on fish and fish habitat is very thorough and the presentation of results is accurate. However, most of the cited material is from studies done in areas outside of Bristol Bay and the direct applicability of results is problematic. This should be done in the revision.

I think that there are potential mitigation measures that were not presented. The primary one, besides the use of bridges, as suggested in the report, is making all culverts be arch culverts. These culverts make use of the stream bottom, which reduces the potential for the culverts to become perched and impede upstream movement, and are less likely to change the gradient than other culvert types. All culverts could, as recommended in the report, be at least one bank width, which is larger than required by the state of Alaska. This would minimize the possibility of plugging with debris.

The review of potential road impacts lacked two possible consequences. One is that roads could be corridors for the introduction of invasive species, plants and animals. The consequences of the successful establishment of non-native species could have critical ecological impacts on native species and the ecosystem. The second consequence is that a road will allow greater access to streams where access was previously limited. Fish populations could be more easily and intensively harvested in sport and subsistence fisheries, which adds additional stresses to the populations. Lee et al. (1997. Assessment of the condition of aquatic ecosystems in the Interior Columbia River basin. Chapter 4. Eastside Ecosystem Management Project. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.) found a direct relation between road access and the status of salmonid populations in the Columbia Basin.

Charles Wesley Slaughter, Ph.D.

No. The Assessment does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

The specific consequences of a failure on salmonid habitat and biology are portrayed well.

John D. Stednick, Ph.D.

No. It is unclear how the estimate that 50% of the culverts would fail was obtained, given that the literature shows a range of 30 to 60% (Section 4.4.4). What literature was used? Are road BMPs satisfactory in this environment? Have the Alaska BMPs been audited? Culvert repair taking a week to several repairs in a month seems high. If the road crosses a critical salmon rearing stream, conservative pipe sizing or bridgework could be considered. The direct loss or inaccessibility of upstream salmon habitat does not necessarily translate to salmon loss. Timing of culvert blocking event with salmon migration and duration of blockage should be considered. Need to include references to Alaska Department of Natural Resources and Alaska Department of Transportation.

What are the design considerations for the culverts? What precipitation/streamflow relationships will be used for sizing purposes? What are the usual casual mechanisms for culvert failure? How much woody material do these streams carry? Do culverts fail from debris plugging, road slumps, or overtopping by storm events? What road BMPs will be implemented?

Roy A. Stein, Ph.D.

Sizing Culverts: Page 5-61. Here the suggestion is that "Culverts must be 0.9 times the ordinary high-water width…" and where the channel slope is less than 5%, the "the culvert is allowed to be 0.75 times" this same metric. Does this take into account global climate changes, which would mean higher flow rates than historically has been the case? Shouldn't culverts be sized larger than what historical flow rates would suggest, given that Climate Change will likely result in more intense storms and therefore greater stream flows than has historically been the case?

Culvert Failures: Page 6-42. Culvert failure rates of 30-66% suggest we are doing something wrong with establishing these culverts to maintain stream flow under a road. How might we reduce this rate of failure (larger culverts? placement issues? solutions of any sort?)? In fact, if indeed 50% of the culverts will be blocked (see bottom of page 6-43), are we not dealing with an unacceptable solution of running streams under roads? Might there be some replacement of these culverts with bridges; certainly, bridges are more expensive to build, but they simply do not have the failure (i.e., blockage) rate that culverts do. Might there be a trade-off here between initial investment costs (high for bridges) and salmon protection (fewer blockage events)? What would Best Management Practices tell us in this context?

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to culvert blockage and failures. Culvert blockages will prevent salmon passage leading to possible effects on reproductive success. Literature data for the incidence of culvert failures were used in assessing failure probability. This seems to be an appropriate approach given the hypothetical nature of the mine used in the assessment; however, this is not my area of expertise and I am not aware of additional data that should be considered.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to culvert failures along the transportation corridor. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to culvert failures along the transportation corridor.

Road and culvert failure likelihood. The likelihood of road and culvert failures is discussed in Section 4.4.4 (p. 4-62). This section relies on the paper by Furniss et al. (1991) for a number of aspects. As was pointed out above, this paper is focused on forest and rangeland roads and is not applicable to the access road for the Pebble Mine. It is recommended that further evaluations be done of similar roads at mines constructed between mines and port facilities to update this section.

Road and culvert failure consequences. The failure consequences discussed in Section 6.4 seem to be based on almost total regulatory failure during and after operations. The information also serves to highlight the aspects that should be considered when designing, operating and maintaining the access road during operations and subsequently during closure.

Phyllis K. Weber Scannell, Ph.D.

The risks to salmonid fish due to culvert failures would be minimized by implementation of permits by Alaska Department of Fish and Game (ADF&G), Habitat Division. Under A.S. 16.05.840-870, Alaska has some of the most protective laws for fish and fish habitat in the United States. Further, given the lack of specific information on road alignments, construction methods and stream crossings, it is not possible to calculate lengths of affected streams, quantify loss of fish habitats, or predict failures of culverts, side slopes, etc. The document would be strengthened if it included specific information on locations of spawning and rearing habitats and estimated the contribution of fish habitats in the Nushagak River and Kvichak River Watersheds to the Bristol Bay fishery.

Paul Whitney, Ph.D.

Criteria for bridge versus culvert installations along the proposed haul road. The dynamic process of beaver dams causing streams to move across the floodplain should also be a criterion for determining if and where culverts are installed for a potential road (pages 4-36 and 4-63). Even if salmonids are not present at a stream crossing, the mosaic of active and decayed beaver ponds in the floodplain can be important rearing areas for forage fish and benthic drift that are utilized by salmonids (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). If beaver dams (but not salmonids) are present above proposed stream crossings, bridges or causeways that allow the streams to move across the floodplain should be recommended versus a culvert.

Beaver are known to block culverts at the upstream ends. Beaver-proof culverts are an option, but all the designs I am aware of would certainly hinder, if not block, movement of forage fish and benthic drift. Causeways or bridges are the best way to encourage beaver activity (i.e., functions) and all the benefits that accrue.

Toxic plume. Spills of transported chemicals are not quantified in the culvert failure section of the assessment. I have participated in a mine risk assessment and a landfill risk assessment where spills of cyanide and landfill leachate have been modeled. While I did not conduct the plume movement analyses, stream hydrologists readily calculated how far spilled materials would move down stream until the concentrations of chemicals in streams reached acceptable benchmarks. The longevity of a spill of chemicals for copper processing should be calculated. It appears that the Water Treatment failure assessment on page 6-39 conducted some sort of plume analysis to determine the potential for an impact on Iliamna Lake. Perhaps it is possible to use this analysis, or at least the model, to address the consequence of a spill of transported chemicals.

Question 8. Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The discussion of pipeline failures is based on published failure rates, principally for oil and gas pipelines. This analysis results in a pipeline failure rate of one per 1,000 km per annum. This is a pretty generic number that does not consider actual pipeline design. Rather it indicates that pipelines designed using standard practices do fail with a fairly high frequency. The Assessment does not apply this failure rate to the gas and diesel pipelines because "they are not particularly associated with mining." Without the mine, there would be no pipeline. So given that this rate of failure is quantifiable based on good data and that the pipeline would be built to serve the project, this risk should be considered.

A concentrate pipeline spill would have differing impacts depending on when and where the spill occurred, with deposition in Lake Iliamna likely being the worst outcome. As noted in the report, it is likely that a pipeline spill would be detected rapidly and that the volume of the spill would be limited and amenable to remediation. A better description of how concentrate pipeline failures have occurred would be helpful to better understand the risk for this project (e.g., the July 2012 Antamina concentrate pipeline failure, although this pipeline would operate under a much different pressure regime due to extreme altitude change).

Steve Buckley, M.S., CPG

The assessment does generally describe the potential risks to fish from hypothetical pipeline failures.

Courtney Carothers, Ph.D.

A pipeline failure would be expected to release toxic leachate into stream systems in the transportation corridor, none of which would dilute the leachate enough to prevent severe toxic effects (both immediate and long-term). The report discusses three pipeline failures in the Bajo de la Alumbrera mine in Argentina. The largest pipeline failure lasted two hours (compared to only two minutes of exposure hypothesized in the current mine scenario). The report could more clearly describe this case and its likely effects. The report appears to appropriately characterize risks to salmonid fish due to pipeline failures, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

The risks to salmonid fish due to release of pipeline concentrate/slurry and leachates (as return water) are well described. However, risks of a diesel fuel spill are not. More detail could be provided on reclaimed water. For example, what toxic constituents (and at what volumes) would be released to the environment if these pipelines failed?

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the pipeline failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. It was clear that the effects of a pipeline failure could be major, depending on the duration and timing of the spill, because of the concentration of metals in the slurry, the particular life-stage present, flow conditions, and the reduced potential to fully remove the material from a stream or wetland afterwards.

The one question that I had about this section was the potential impact on phytoplankton and zooplankton in Lake Iliamna, particularly at the local scale. I assume that any spill from pipeline failure would have potential impacts on the lake and on phytoplankton and zooplankton, the major food for juvenile sockeye salmon. The ecological consequences would depend on the extent and intensity of any spill and on how juvenile sockeye use areas near tributary streams. I would expect that a spill could be particularly detrimental if juvenile sockeye use the area near or adjacent to natal streams when they enter the lake. I think this should be considered in more detail in any additional analysis.

Charles Wesley Slaughter, Ph.D.

No. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. On-site investigation may well reveal many more "watercourses," including intermittent and ephemeral streams, than the 70 crossings cited; possible pipeline failures thus may have much wider potential for impacting salmonids than is indicated in the Assessment.

The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there would be only 1.5 stream-contaminating spills or two wetland-contaminating spills over 78 years of operation seems wildly optimistic (and what is half a spill?).

Assuming that any spill (over the 78-year project span) would last only two minutes (p. 6-32, p. 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident.

The specific **consequences** of a failure on salmonid habitat and biology are portrayed well.

John D. Stednick, Ph.D.

The pipeline corridor consists of four pipelines over a distance of 86 miles. No information was provided on pipeline structure or placement, other than mentioning of stream crossings. The pipeline failure of concentrate slurry was modeled using chemistry from the Aitik (Sweden) mine. Is this best approximation? That mine is about 80 years old and is processing ore from the edge of the pit, with much lower sulfur content than Pebble.

Pipeline failures can be significant in any environment and spill or pipe break prevention requires significant monitoring. Will automatic shutoff controls be included? Are workers stationed 24 hours/day every day? Some of the past Alaska failures were in winter conditions, when things were not easily visible--under ice or snow cover. How will this be addressed?

The toxicity approach seems reasonable. What is the anticipated chemistry of the return waters? Diesel spill monitoring? The geometric mean of three values (which references) indicates that there is a 14% probability of failure in each pipeline in each year. This is not acceptable at any level.

Roy A. Stein, Ph.D.

Pipeline Failures I. What dictates 14 km between automatic shut-off valves; shouldn't this distance be shorter as the pipe becomes larger, i.e., related to the amount of liquid/slurry that would be spilled upon pipe failure? Shouldn't all of these pipelines be double-walled? What would Best Management Practices tell us in this context?

Pipeline Failures II. Like all other failures, it seems to me that "Standard Operating Procedures (SOP)" for mitigation should be in place in anticipation of any future spill or contamination of the environment. I do not think that these procedures need to be in this report, but an acknowledgement of their presence and that mining companies will follow these SOPs in response to any spills that occur, be it pipeline, TSF, truck, leachate bed, etc.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to potential pipeline failures as part of the risk assessment. This evaluation focused on potential failures associated with the pipelines for the product concentrate slurry and return water. No consideration of the natural gas or diesel pipelines was presented, stating that such pipelines "are common and the risks are well-known." Although I would acknowledge the failures in natural gas and petroleum pipelines are common, I would not discount the potential effects to salmon populations associated with such spills.

Evaluation of potential impacts due to a spill of product concentrate slurry or return water was based on extant data from an existing copper mine in Sweden; to the extent that this slurry and return water is representative of similar materials coming from the Pebble mine, this approach is appropriate. The assumptions used in the amount of material that might possibly be spilled seems appropriate and based on past experience and realistic assumptions; however, these assumptions need to be reconsidered if and when a real mine plan is prepared.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to pipeline failures. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to pipeline failures.

Pipelines failure likelihood. The EPA Assessment focuses on the failure of the concentrate pipeline because "We do not assess failures of the natural gas or diesel pipelines here because such pipelines are common, their risks are well known and they are not particularly associated with mining". I find this statement puzzling because all pipeline failures should be of concern. It is further puzzling because the likelihood of pipeline failures for the concentrate pipeline is derived from the failure statistics for pipelines in the oil and gas industry (p. 4-60). Failure of the Baja de la Alumbrera concentrate pipeline in Argentina is suggested as an analog, indicating that such failures can occur; however, I disagree that "it suggests that concentrate pipeline failures are common at a modern copper mine." This last statement is not supported by any further analysis of concentrate pipeline failures at other modern copper mines. It is recommended that such analyses be performed or that the text be edited to indicate this shortcoming.

Pipelines failure consequences. Failure consequences are focused on the release of concentrate into water. As indicated in Appendix H of the report, the analog concentrate from the Aitik mine is dominated by chalcopyrite, a sulfide mineral which contains the copper. If the concentrate is submerged under water in relatively slow flowing streams then very little long-term release of the copper will occur, as the water does not contain sufficient oxygen to allow for sulfide oxidation. It is only when the concentrate is transported to locations above the water level that oxidation and release of metals will occur.

Phyllis K. Weber Scannell, Ph.D.

This section of the document focuses on effects of pipeline failures; however, without a viable mine plan, descriptions of pipelines and estimates of possible effects are speculative. The resource developer may opt to build a pipeline to transport fuel from the coast to the mine site or slurry concentrate to the port. Construction of any pipelines would require review and approval by state and federal agencies, such approvals would likely contain monitoring plans to ensure pipeline integrity. However, the risks of pipeline failures should not be minimized; the Fort Knox Mine near Fairbanks recently experienced a 45,000 gallon spill of cyanide solution after a bulldozer struck a supply line (Fairbanks Daily News Miner, August 24, 2012).

The risks of a pipeline failure to salmonid fish depend on the duration of the spill, the type of material spilled (return water or concentrate), the location of the spill (in the uplands or in a waterway), and the timing. The effects of a pipeline failure in a waterway when juvenile salmon are present would be far more severe than a pipeline failure in an upland area.

Given that there currently is no information on road alignments or locations of future pipelines, it is not possible to estimate the number of stream crossings (70, page 6-30) or an exact length (269 km, page 6-30) of potentially affected waterways. The risks from pipeline failures outlined in the draft document should be revised when more specific information on the mine plan of operations becomes available.

Paul Whitney, Ph.D.

See responses to Questions 2 and 7.

Question 9. Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The Assessment generically describes tailings dam failures and the potential impact in detail. It also uses some site-specific information on tailings supernatant and humidity cell leachate. There is no question that a tailings dam failure would be catastrophic for the fishery and the project, and although low probability, is the single largest risk to the fishery. A tailings dam failure could harm a very large area of the watershed for a very long period of time and could require a massive and expensive remediation effort.

The tailings deposition and storage methods outlined in the Wardrop NI 43-101 report and presented in the Assessment are conventional for the industry and comply with Alaska State regulations. Because of the dire consequences of a failure in this highly sensitive and unique environment, it would be necessary to employ state of the art methods for tailings management and go 'beyond compliance' when designing and constructing this facility. This may include employing methods that are novel, incur significant additional cost for construction, and lead to a more stable and lower maintenance facility in the long term, such as dry stack or paste rock tailings (blending waste rock in with tailings in the impoundment to provide extra geotechnical stability). These methods, however, are not common practice and in some instances are still under development.

Steve Buckley, M.S., CPG

The assessment does generally describe the potential risks to fish from tailings dam failures.

Courtney Carothers, Ph.D.

In the event of a tailings spill, invertebrates and fish would be exposed to toxic tailings and leachate. Actual tailings failure examples suggest the range of exposure would spread to an area more than 100 km. Copper would be especially toxic to invertebrates, fish eggs and larvae. Toxicity would last for decades. The report appears to appropriately characterize risks to salmonid fish due to a potential tailings dam failure, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

Tailings deposition is described in Chapter 4 of the main report, but I could not find anything that described potential risks to fishes, including effects to aquatic food webs and loss of fish spawning and rearing habitat. As noted in the text, the sediment transport model used could only simulate sediment transport and deposition ~30 km downstream of the mine site. Thus, potential effects to fish habitats were not well quantified for the mainstem Koktuli River (and beyond), in addition to the Mulchatna and Nushagak rivers. Is there a likelihood that any tailings material might reach Lake Illiamna? If not, say so in the document. It is equally useful to say where impacts will not occur (as it relates to sensitive habitat) as it is to describe where impacts are likely and reasonable.

The assessment deemed that it was "not possible" to determine how far the initial slurry deposition would extend, how far re-suspended sediments would travel, and how long erosion processes would continue. It seems that information from other mine closure sites could be used by assessment authors to infer effect by analogy. The statement alluding to potential sediment run out distance at the bottom of page 4-56 of the main report should be included in the summary of effects. This is an important point.

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the dam failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. Impacts, like those of a pipeline failure, are likely to be widespread in the watershed and to be long lasting, resulting from inundation of areas by sediments and contaminants in the water. I think that potential impacts across the broader scale could be developed and highlighted more fully. Also, consideration of Intrinsic Potential (see response to Question 4) could provide additional insights into potential impacts of a tailings dam failure.

I think that potential consequences of climate change on hydrographs should have been considered in this section. More precipitation is projected to occur as rain in the winter rather than snow for many parts of AK. How would this potentially impact the tailings dam facilities? This seems to be a key piece of information that is needed to better understand the risk of dam failure and the potential for impacts on aquatic resources.

I thought that results to date of the impacts of the volcanic eruption at Mt. St. Helens, while not exactly the same as a mine operation, were not useful in considering long-term impacts and the response of aquatic ecosystems to such major disturbances. The impacts on streams are still more prevalent and extensive than what is described in the report. Most stream systems are transporting large amounts of fine sediment and areas of exposed gravels are rare.

Charles Wesley Slaughter, Ph.D.

Yes. Physical consequences of TSF dam failure are fairly portrayed. I would only suggest that effects of initial sediment deposition and long-term remobilization and redeposition would extend beyond the spatial and temporal limits of the modeling used in the Assessment.

Employing advanced eco-hydraulic modeling tools such as MIKE-11, MIKE-SHE (DHI, Copenhagen), and consultation with state-of-art practitioners (IAHR-International Association for Hydraulics Research, UI Center for Ecohydraulics Research, and others), along with improved high-resolution input data such as LIDAR survey of the complete Kvichak and Koktuli/Nushagak systems, would allow a more complete estimate of potential hydrologic and sedimentation (and consequently biotic) consequences of TSF dam failure for the entire river system, headwaters to Bristol Bay.

John D. Stednick, Ph.D.

The tailings dam failure was modeled and the distance of sediment transport was estimated. The modeled tailings dam failure used an estimate of 20% mobilization from the tailings ponds. How was this value determined? The model was run to a stream length of 30 km (the rivers confluence), yet the report acknowledges that a sediment pulse could run for hundreds of kilometers. The moisture content of the tailings is estimated to be 45% by volume (page 4-50); the 20% volume of sediment may be underestimated. This initial risk to salmonid fish is clear, but the persistence of the sediment affect could be discussed.

The Mount St. Helens analogy is inappropriate for a variety of reasons and such comparisons should be removed from the assessment.

The probable maximum precipitation (PMP) value was extrapolated from Miller (1963) and the assessment commented how this value might be reduced upon further analysis. Conversely, additional data could increase this value. There was no discussion of the recurrence interval of this 24-hour storm.

No hydrologic data were provided. The streamflow gauging stations operated by the US Geological Survey near the study area suggest peak streamflow rates from snow melt and from rain events. The hydrograph shape and magnitude help determine if rain or snowmelt dominated. In the assessment, the peak flow estimate from the Natural Resources Conservation Service runoff method used a Type 1a storm distribution, the least intense precipitation distribution, but the literature would suggest that a Type 1 distribution would be more appropriate for Alaska. How does this storm event compare to the measured flood at Ekwok (page 4-50)? The curve number (CN) was not identified, nor the methods used to calculate that value. Similarly, the watershed slope, time to peak, hydraulic length, channel routing functions, and channel resistance methods or results were not presented. What precipitation data are available? The design of culverts, bridges, and storm water ponds all require good precipitation records and the confidence in that estimate is based on record length.

The comparison is unclear for a 3,313 m^3/s flow in a 2,551 km^2 watershed area to the TSF flow of 1,862 m^3/s and an area of 1.4 km^2. What was the precipitation and recurrence interval for the Ekwok storm? The relation of groundwater flows to streamflow during storm events needs to be evaluated. The flood producing precipitation events in this area no doubt add to groundwater flows.

With a new estimate of precipitation depth of known recurrence interval, the design storm could result in a higher flood event with greater velocities and greater sediment transport ability, along with a greater sediment volume released from the TSF, resulting in a greater risk to salmonid fish and habitats.

Roy A. Stein, Ph.D.

TSF Failure and Remediation. The text on pages 6-1 to 6-2 states:

> "Remediation may occur following a tailings spill, but it is uncertain. A spill would flow into a roadless area and into streams and rivers that are too small to float a dredge, so the proper course of remediation is not obvious."

At this juncture in time, this statement points to the fact that we do not have the technology, or the appropriate operating procedures, in place to remediate a TSF spill. Does this essentially let the mine operator "off the hook"? Should we be promulgating mining activities in locations where we cannot remediate spills, given our current state of knowledge or ability to apply current techniques? What guidance would "Best Management Practices" provide for this situation?

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to tailings dam failures. Tailings dam failure would potentially result in the release of large volumes of mine tailings and associated contaminated waters, leading to possible acute and long-term effects on salmon populations. It is also important to note that direct effects on salmon may be very species dependent, due to life-cycle differences, and the time at which the dam failure occurs. Potential effects due to sediment inundation/impaction can adversely affect habitat, leading to decreased spawning. Evaluation of the potential for tailings dam failure effects considered acute and chronic risks due to aqueous exposures, chronic risks due to sediment exposures, and risks due to dietary exposures. All of these seem to be appropriate exposure pathways and all were adequately considered, although site-specific information will improve risk predictions.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential tailings dam failure. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential tailings dam failure.

TSF failure likelihood. The failure statistics given on p. 4-45 are based on tailings failure statistics over the last 50 years or so. Was there also a review of the operational histories, and therefore failures, of tailings impoundments designed and constructed in the last 10 to 15 years? It is recognized that one of the failures identified in Box 4-4 (Aurul S.A. Mine, Baie Mare, Romania) falls in this category. However, many of the failures included in the analyses are associated with older tailings facilities, especially those associated with large releases of tailings solids. A significant improvement in tailings management is the implementation of an Independent Tailings Dam Review Board (ITRB) for large mining projects (Morgenstern, 2010). An example of the activities of an ITRB is given in Minera Panamá (2012). Morgenstern (2010) provides a listing of tailings failures from 2001 and 2010 and comments that "in no case, to the knowledge of the Writer, was there systematic third party review" of the failed facilities as would be the case when an ITRB is active. I expect that a tailings review board will also be used for the Pebble Mine and the behavior of a tailings management facility designed and operated under these conditions will be more representative of the potential failure likelihoods expected for such a facility. It is expected that this likelihood will be much lower than those used in the evaluations of the scenario in the EPA Assessment.

TSF failure consequences. It is difficult to estimate the volume of tailings that will be released when a tailings impoundment fails. The release of 20 percent of tailings from a slurry deposited TSF may be realistic when it contains a large pool and is subjected to a large flood, but it is unrealistically high for a TSF containing a small or no pool (such as in the case of a filtered dry stack). I would consider the assumption that a release of 20% of the tailings material for the Pebble mine scenario is on the high side, even during operations. When the mine is closed and the tailings reclaimed I would consider the 20% release assumption as unrealistic, especially if the closure implementation included a diversion system designed for the PMF. It is further unrealistic to assume that the released tailings will remain in the downstream channels and flood plains following the failure. In the case of the Aznalcóllar Tailings Dam failure in Spain, all the released tailings downstream of the mine were removed. While such a removal action will impact parts of the watershed, it will help to recover the area faster than leaving all the tailings in place and will also reduce the longer-term impacts on downstream water quality. I therefore disagree with the assumption on p. 6-2 that "the assessment assumes that significant amounts of tailings would remain in the receiving watershed for some time and remediation may not occur at all." Box 6-1 provides "background on relevant analogous tailings spill sites" and three historic sites are used as analogs. These are not realistic analogs, as they all relate to historic mining under completely different scenarios. While the material historically released in these streams were from base metal mines, the circumstances of their release, especially in the case of the Clark Fork and the Coeur D'Alene Rivers, were very different. Long-term uncontrolled releases occurred in these river systems due to regulatory circumstances or historically acceptable practices that differ significantly from those in the 21st Century.

Phyllis K. Weber Scannell, Ph.D.

The assessment considers two possible failures of the tailings dam: a partial-volume failure occurring during mine operations and a catastrophic failure occurring during or after mine operations. The partial-volume failure (as modeled in the assessment) would result in a greater than 1,000-fold increase in discharge and the catastrophic failure in a greater than 6,500-fold discharge.

The discussion of tailings dam failures describes possible changes in channel and floodplain morphology and briefly mentions that the tailings deposition would be a source of easily transportable, potentially toxic material.

The potential for increased metals loadings to river and lake systems is understated. Although there are no current predictions of tailings water quality, the water quality of tailings water from similar mines could be used to model increases in metals loading from dam failures.

In addition to the partial-volume failure and the catastrophic failure, there are other possible sources of metals loadings from the tailings pond. Examples are emergency releases of untreated tailings water, seepage of tailings water into the groundwater, and flow from the tailings pond to groundwater in an adjacent drainage as the head (i.e. hydrostatic pressure) is increased as the tailings pond is filled. The last example was experienced at the Red Dog Mine when the increased elevation of the tailings pond caused water to flow underground into the Bonns Creek drainage instead of the Red Dog Creek drainage. Interception ditches were installed after the increases in metals loading to Bonns Creek were detected.

Paul Whitney, Ph.D.

Duration. I agree with the assessment that it would take a "very long time" (page 6-25, first full para, last line) to reach concentrations that would not exceed threshold exposure levels. A "very long time" could mean hundreds of years to one person or geological time (i.e., millions of years) to another person. The assessment could be improved if some sidebars are put on the time likely required for no risk dilution or "more normal channel and floodplain." One suggestion would be to estimate the amount of time it would take the river/stream to move across the floodplain in the "relatively undisturbed" Bristol Bay watershed. I would also like to know whether reclamation or rip rap or rock weirs in areas with spilled tailings would reduce or extend the time to reach "more normal" conditions.

Question 10. Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The assessment does a good job analyzing the importance of fish resources to other wildlife and to Alaska Native communities. The lack of site-specific information in the report results in only very general conclusions that there 'would be some effect.' Of course, wildlife in the project area and any traditional use of these lands would be affected by project construction under the no-failure scenario. However, due to the lack of information, it is unclear if this is an area rich in other wildlife or if there are traditional native land users that rely on the area. Although the conclusion of this section is necessarily general, it would be helpful to have more detailed characterization of wildlife and native use in the project area.

Under the failure scenario, a tailings dam failure, in particular, would be catastrophic for wildlife and Alaska Native communities that use the area.

Steve Buckley, M.S., CPG

Analyzing the risks to wildlife and human cultures is beyond my scope of expertise.

Courtney Carothers, Ph.D.

Wildlife: The sections discussing risk to wildlife resulting from effects on salmonids are fairly short. Those animals that directly feed on these fish are likely to be impacted, as well as those that depend on other resources enhanced by the marine-derived nutrients supplied by salmon carcasses. The report concludes that the primary aquatic contaminant is copper (5-75), but notes that the ore processing chemicals are unknown, as are their toxicities (5-59). These unknowns could be noted as potential contaminants.

Human cultures: Overall, the main report (and Appendix D) describes the central role that salmon play in both Yup'ik and Dena'ina culture, both traditionally and in contemporary communities. As noted above, the scope of the assessment focusing on these two cultural groups should be made more clearly. Appendix E, for example, focuses on other human groups local to this region, and those who migrate to the region for commercial fishing and recreation, who may also be affected by risk to fish in this region. The vulnerabilities listed in Appendix D (p. 4-5) could be listed in the main report more clearly as risks.

Literature on the effects of contaminated or declining resources on subsistence communities could be utilized to describe likely impacts in more detail. For example, the report notes: "the actual responses of Alaska Native cultures to any impacts of the mine scenario is uncertain" (ES-26). While the specific responses are uncertain, likely responses can be predicted (and many are articulated in Appendix D). There are data on the psychological, social, cultural, and economic disruptions caused by the Exxon Valdez oil spill (e.g., Braund and Kruse 2009; Palinkas et al. 1993), the cumulative effects of oil and gas development in the North Slope region (e.g., Braund and Associates 2009; NRC 2003), and social impacts related to mining development in Alaska (e.g., TetraTech 2009; Storey and Hamilton 2004). Drawing on some of this literature could help provide likely scenarios for impacts to Alaska Native subsistence-based communities from decreased quality, quantity, or diversity of salmonids. Current and recent responses to salmon shortages in the Yukon-Kuskowkim region may also be helpful to include.

Clearly the impacts to subsistence are not just lost food sources, but loss of healthy subsistence lifeways, loss of practices, loss of cultural connections to the past, loss of connection to specific places, loss of teaching and learning, loss of sharing networks, loss of individual, community, and cultural identity, among others as detailed in Appendix D. This point could be made more forcefully. As noted above and detailed in the specific comments below, subsistence is framed at times in the report as primarily important for physical health and economic necessity. The cultural, social, psychological, and spiritual aspects of subsistence livelihoods should also be consistently highlighted.

As discussed Appendix D, Alaska Native cultures in this region and other regions in the state are also dependent upon the cash economy, both for subsistence production and for other needs. The role of commercial salmon fishing or other wage engagements related to salmon in the study communities, while discussed in Appendix E, is not given much discussion in the main report. How dependent is the subsistence economy upon commercial and recreational fisheries and in this region?

There is a brief mention of non-fish related impacts to Alaska Native communities in the main report (5-77). Unless a full treatment of these impacts (positive and negative) is included, these paragraphs should be removed. While in general, I am supportive of an increased scope (i.e., it is incredibly difficult to isolate only salmon-mediated impacts to Alaska Native communities), these other economic, social, and cultural impacts are not presented fully in the analysis, nor was the ethnographic research designed to investigate these impacts, so passing mention of them here does not seem appropriate.

Dennis D. Dauble, Ph.D.

There is considerable detailed information in Appendices D and E relating to impacts of the project to the economy. This information includes how salmon affect all segments of the population, such as cultural resources of Native Peoples. However, not addressed in detail were long-term impacts to Native Peoples that might occur after losing a way of life that includes salmon. The description of potential impacts to their health and welfare should be expanded. There are numerous examples of how Columbia River tribes have been negatively impacted due to loss of fish resources (and fishing as a lifestyle) as a result of dam construction. These impacts go beyond simple economics.

The report should include a discussion of effects specific to unique user groups. That is, some communities rely almost solely on sockeye; kings are more important to others. These impacts could be segregated by watershed, for example. Also, some groups have more option for subsistence gathering if sockeye and Chinook salmon resources are impacted. Potential impacts of a declining salmon population due to mining operations would be less for them than groups "on the edge" who currently rely mainly on salmon.

Disturbance of wildlife from noise and roadways should be included with respect to migration corridors and critical habitat. Highlight species most likely at risk from human disturbance, habitat loss/displacement (from the project footprint), and loss of salmon. For instance, do some piscivorous species have the ability to shift their diet to include another source of protein? If so, how would this shift affect the human culture with reference to a subsistence lifestyle?

Gordon H. Reeves, Ph.D.

These topics are outside my area of expertise so I cannot comment on if the report adequately characterizes the risk to wildlife and human cultures. I am familiar with some of the literature on the importance of salmon to wildlife and the report represents the finding fairly and accurately. I cannot provide any additional literature, reports, or data.

Charles Wesley Slaughter, Ph.D.

No. The Assessment clearly qualified that its objective was to consider risks to salmonids, and only inferentially consider "salmon-mediated" effects.

Appendix C provides a comprehensive discussion of non-fish wildlife and the relation of those populations to salmon. However, the Assessment itself (Volume 1) provides only a brief summary in Chapter 2.2.3, which could allow a cursory reader to perhaps conclude that wildlife populations have little risk of impact from the hypothetical Pebble project. Is this the intent of the Assessment authors? A more in-depth reading of Appendix C allows inferring potential consequences to wildlife and birds of "salmon-mediated" impacts of mining development.

Appendix D provides a comprehensive and useful discussion of the indigenous people of the Bristol Bay region and of their traditional ecological knowledge and cultures. Appendix D clearly lays out the vulnerabilities and risks (summarized on p. 4-5 and pp. 150-153) associated with the (hypothetical) major resource extraction projects. However, the Assessment (Volume 1) provides only cursory consideration of these human aspects of the potential project – on p. ES-23, and in Section 2.2.5. Presumably, this is because the EPA mandate is to conduct an ecological risk assessment, rather than assessment of consequences for human populations, whether indigenous, native, resident, non-native, non-resident, or the larger cash economy world as represented by the State of Alaska, Northern Dynasty Minerals, or Pebble Limited Partnership.

John D. Stednick, Ph.D.

The effect on wildlife section largely focuses on the return of nutrients to the land in various shapes and forms and adds little to the risk discussion. Other than marine-derived nutrients, other stressors exist. What are the consequences of the mine operation on other wildlife habitats? Habitat fragmentation? Noise and light disruptions, etc.?

Mine development will require the use of explosives. What are the effects of the nitrate and ammonia in the air following each detonation? The National Trends Network data suggest that the area receives about 1 kg/ha/yr of nitrogen in precipitation. Thus, the increase in atmospheric inputs from the explosions may exceed the marine-derived nutrients. What are the consequences?

The potential loss or change in lifestyles of indigenous peoples is important, but this information seems relegated to Appendix D. Include more of this information in the main body of the text. Actually, there is a significant amount of information in the appendices that should be brought forward.

It is unclear why there is such variability in the detail or depth of assessment of each of the stressors. Why does the TSF failure section have 34 pages while the section on potential effects on native peoples only has a few pages with a reference to an appendix? The unevenness of the coverage needs to be addressed.

Roy A. Stein, Ph.D.

Risks to Wildlife. The importance of salmon in bringing Marine Derived Nutrients (MDN) into these freshwater ecosystems and watersheds and their role in influencing wildlife and associated interactions between wildlife and human cultures was well described. Loss of these nutrients would severely compromise wildlife, and thereby human (through reductions of subsistence harvest), populations. The appendix dealing with wildlife was quite detailed and well done and it would serve the main report well for the authors to include critical information from this appendix.

Risks to Native Alaskan Culture I. I thought that the assessment could be approved if the same approach used for the mine, i.e., a case history approach, was used for human cultures. Surely, there exist situations where salmon have declined or have been reduced by development/exploitation (the Fraser River, perhaps?) where subsistence by Native Alaskans was historically paramount. Once the salmon were reduced, what was the impact on the Native Alaskans subsistence culture? How did the Native Peoples respond? From whence did they get sustenance, cash, etc.? What sort of displacement occurred?

Risks to Native Alaskan Culture II. The only risks reviewed here came via salmon-mediated impacts on the culture of Native Alaskans. Direct impacts of the mine through jobs (potentially positive), wildlife (likely negative), etc. all could be discussed briefly, serving to broaden the overall impact of the mine and its associated activities on Native Alaskans.

Risks to Other Cultures. I was a little surprised that little text was spent on recreational anglers, commercial fishers, subsistence users (other than Native Alaskans), etc. Appendices provide some guidance here and this text need not be voluminous, but mentioning these impacts of the mine on these groups would improve the main report.

William A. Stubblefield, Ph.D.

Potential effects to wildlife and human cultures are briefly addressed in the risk assessment. No "quantitative" assessment of potential effects is provided. For the most part, it appears that potential affects to both wildlife and human cultural endpoints are directly proportional to the injury suffered by salmon populations as a result of any spills or failures. Given the level of detail available at this point in time regarding mine operations and closure, that is probably about as far as any assessment could go. I'm not aware of any literature reports or data that would assist in further characterization of these potential injuries.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to wildlife and human cultures due to risks to fish. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to wildlife and human cultures due to risks to fish.

I am not an expert on wildlife and human culture and cannot provide any further information in the forms of literature, reports and data not referenced that would be useful to characterize these risks.

Phyllis K. Weber Scannell, Ph.D.

The document focuses on effects to wildlife that would occur from failures – tailings dam failure, pipeline failure, etc. There are other sources of disturbance to wildlife that should be addressed in a future mine plan and agency review and permitting. Other mines in Alaska limit truck traffic on the haul road during caribou migrations, incinerate all kitchen waste, educate workers on bear safety, and prohibit inappropriate disposals of food containers or other wildlife attractants. Other factors that might need to be addressed to protect wildlife are limiting air traffic and noise during certain times of the year. Unless addressed, these issues are more likely to cause detrimental effects to wildlife than dam or pipeline failures.

Addressing issues related to effects on human cultures is outside my area of expertise.

Paul Whitney, Ph.D.

<u>Problem Formulation for Wildlife.</u> If one addresses the problem formulation for wildlife at face value, the answer is pretty straight forward. The assessment tells us that the consequences of loss and degradation of habitat on fish populations could not be quantified because of the lack of quantitative information concerning salmon, char, and trout populations (page ES-26, third bullet). Furthermore, we learn that indirect effects, such as risks to wildlife, cannot be quantified (page 5-75, para 1, last line). Stating that reduced salmon production would reduce the abundance and production of wildlife (page 5-75, para 1, last sentence) is accurate but not appropriate for a document that is intended to provide a scientific and technical foundation for future decision making (page ES-1, para 1, last sentence). It is certainly possible to provide a more complete scientific and technical response to a question regarding impact to wildlife. I respectfully suggest that the first step in developing a more complete scientific and technical response is to modify Question 10 by deleting the words "due to risks to fish" and to separate the risk analysis for wildlife from the risk analysis for human culture. A revised wildlife question should address both indirect and direct risks. A revised human culture question should address (among many other risks) both direct and indirect risks to fish and wildlife.

<u>Mixed Messages.</u> The assessment and questions given to the review committee give mixed messages regarding the scope of work. A variety of statements and conclusions in the assessment are inter-related, as one would expect for a document that addresses ecosystem issues. While acknowledging the overlapping issues and responses, I offer the following discrete points that give me mixed messages regarding the scope of work and an appropriate characterization of risks to wildlife. Since these points are related, there is some repetition of information but each of the following items address a discrete issue.

1. The PREFACE (para 2) clearly states "Our goals in conducting this assessment are to complete an objective assessment of the potential impacts of large scale mining on aquatic resources in the Bristol Bay watershed." This statement is subject to wide interpretation by this reviewer and by the document itself. For example, aquatic resources include many species of wildlife and the Cederholm papers indicate that there are 137 species of wildlife that are associated or closely associated with fish. Wildlife species and their associations are aquatic resources but have been glossed over in the assessment. The lack of follow-through in implementing the above goal statement (i.e., not addressing aquatic wildlife and wildlife associated with fish) is problematic. One can readily understand that timing and budget constraints result in some statements indicating that data are just not available or that certain types of modeling, while possible, were not conducted. However, it is difficult to understand why potential impacts to wildlife are

limited to indirect effects due to loss of fish if the assessment was truly conducted as an assessment of aquatic resources. The message is mixed because the goal is to assess aquatic resources, but many aquatic resources are not assessed.

2. The assessment was supposedly conducted as an ecological risk assessment (Abstract, line 5). One of the first steps of an ecological risk assessment is to state well defined endpoints. Suter (1993, page 22) presents 5 criteria that any endpoint should satisfy. My notes are in brackets.
    a. Societal relevance (Assessment appears to do a good job of identifying concerns of people living near the area of the proposed mine. Yet, many of the potential endpoints listed in site models (e.g., Figure 3-2E) are not addressed. The reason for not assessing endpoints in the site models (such as wildlife quality and quantity) should be provided. Better yet, clearly state both direct and indirect endpoints for wildlife.)
    b. Biological relevance (The biological – especially ecological – relevance is incomplete. Wildlife and the functions they provide are relevant in that wildlife comprise many of the secondary and tertiary consumer species in the ecosystem. The upland and aquatic habitats utilized by wildlife are the indirect and direct sources of many nutrient and energy inputs to fish in the Bristol Bay ecosystem. The upland components of the Bristol Bay ecosystem should be assessed in more detail to provide a biologically relevant assessment. If not, the assessment should directly indicate why not).
    c. Unambiguous operational definition (Overall a good job for a hypothetical mine. See response to Question 2 for suggestions).
    d. Accessibility to prediction and measurement (The inability to estimate the impact on salmon numbers is problematic. Is the inability due to a lack of population data, the unwillingness to utilize peer-reviewed methods other than demographic population modeling, or some other reason? Furthermore, the potential reduction in marine-derived nutrients and the potential impact on wildlife can be assessed and predicted – see below).
    e. Susceptibility to the hazardous agent (The assessment does a good job on the hazards for aquatic resources but not susceptibility to wildlife biotic (e.g., loss of habitat) and abiotic stressors (e.g., ice dams and scouring, as well as hydrographs and sedimentation influence on ecological succession). Furthermore, an adequate ecological risk assessment should address ALL ecological stressors (e.g., loss of habitat and disturbance) not just toxics).

    Suter's five criteria should be addressed when selecting endpoints. All the endpoints selected and illustrated in figures should be assessed. The incomplete assessment of quantitative estimates of all the impacts on salmon, non-salmonid fish, wildlife, as well as community and ecosystem parameters should be remedied.

3. A complete assessment of aquatic resources as stated in the PREFACE should address both direct and indirect risks to the many species of wildlife and wildlife habitat that are aquatic resources and closely associated to aquatic resources. The list of all the aquatic species and habitat is lengthy. A partial list of categories of wildlife and wildlife habitats that are aquatic resources includes grebes, ducks, shorebirds, beaver, muskrat, otter, mink, and riparian, emergent, and aquatic vegetation. The impact of mining on all of the aquatic resources is given scant coverage in the assessment, with the possible exception

of impact to wetlands. The PREFACE provides wide ranging goals but the assessment has many gaps, and I wonder why.

4. The Executive Summary (para 1) indicates "…USEPA launched this assessment to determine the significance of Bristol Bay's ecological resources and evaluate the potential impacts of large-scale mining on these resources." The emphasis on salmonids does not fairly represent the entirety of ecological resources. To me, ecological resources should include ecological parameters such as plant community succession, species diversity, energy flow, and structure and function, in addition to the information on salmonids.

5. The Scope of the assessment (ES-,1 last para) indicates that "wildlife … as affected by changes in the fisheries are additional endpoints of the assessment." This informs the reader that only wildlife species that are affected by changes in the fisheries will be an endpoint. Yet many species of wildlife that are affected by changes in the fisheries are not addressed. In addition, such an endpoint glosses over the importance of assessing fish that are affected by changes in wildlife. For example, beaver modify aquatic habitat and terns prey on fish. The scope of the assessment seems to brush over many of the important fish and wildlife interactions discussed by Cederholm et al. (2000) and Cederholm et al. (2001) and to focus mainly on marine-derived nutrients. I am pleased with the discussion of the marine-derived nutrients but am not clear how the emphasis on this one interaction, which is not quantified in the assessment, furthers the understanding of potential mining impact on the Bristol Bay ecosystem.

6. Gende et al. (2004) use a variety of methods to quantify both the marine-derived nutrients and energy that transfer from salmon to terrestrial wildlife and habitats. For example, they determined that bears moved nearly 50% of the salmon-derived nutrients and energy from streams by capturing salmon and dragging the carcasses from the stream. Gende has also worked with University of Alaska Associate Professor Mark Wipfli (Gende et al. 2002) on the relationship of salmon to terrestrial habitats. Alaskan and national experts are likely available to assist EPA in quantifying the movement of marine-derived nutrients to the terrestrial ecosystem.

7. As mentioned above, the assessment does a fine job of emphasizing the importance of marine-derived nutrients transported to the terrestrial environment but has relatively little information on the importance of terrestrial-derived allochthonous nutrients transported to the aquatic environment. Doucett et al. (2007) discuss methods for measuring terrestrial subsidies to aquatic food webs using stable isotopes of hydrogen. The potential loss of terrestrial subsidies due to mining might be as great as a potential reduction of marine-derived nutrients. It would be informative to discuss the relative importance of marine-derived, autochthonous, and allochthonous nutrients. Such information might influence "best mining practices" and reclamation that can partially compensate for lost allochthonous inputs.

8. Figure 3-2E indicates wildlife quality, quantity or genetic diversity, as well as wildlife predation are important to Alaska Native Cultures. Tribal elders are said to have concern for "potential direct effects on other subsistent resources" (which includes wildlife and vegetation). In addition, Appendix D comments on concerns regarding wildlife (e.g., caribou) and vegetation (e.g., berry gathering) that are not directly linked to the fisheries.

An assessment of the direct impact of potential mining and the ongoing exploration on wildlife and vegetation would address the concerns mentioned above. Once again, I wonder why the site model figures outline so much detail that is not addressed in the assessment text.

9. Comments in the main assessment Volume 1 (page 5-76, first lines) indicate that information on wildlife and potential direct impacts are being collected but are not included. Including measures of direct wildlife impact in addition to indirect impact as a result of changes in fisheries would greatly improve the assessment. There are many ways to estimate the impact of habitat loss on wildlife (Morrison et al. 1998). A better understanding of impacts on wildlife would presumably provide a better technical basis for designing a reclamation plan.

10. The assessment (page 5-77, last sentence) states: "Although this assessment is focused on salmon, the non-salmon-related impacts on native cultures from routine mine operation are likely to be more significant…" If this is in fact the case, what better reason could there be for increasing the scope to include wildlife, vegetation, community, and ecosystem structure and function (i.e., non-salmon)? Methods and mine-related examples for assessing such an increased scope are available from the Northwest Habitat Institute (nwhi.org) in Corvallis. Discussions with Tom O'Neil, Executive Director, indicate that available data from the Alaska GAP Analysis Project and the Alaska Natural Heritage Program could likely be used to make such assessments.

11. The risk assessment's focus on "indirect effects on wildlife" (page 5-1, para 2) is consistent with some of the several goal statements that lean toward fish influence on wildlife. I have difficulty reconciling this emphasis because further on in the text (page 5-75, para 1, last line) it is stated that the "indirect effects cannot be quantified." If the indirect effects cannot be quantified, one should think it is even more important to get a handle on the direct effects, which can be assessed by any one of several wildlife methodologies (Morrison et al. 1998).

12. The assessment indicates the exceptional quality of the fish populations and their importance to the region's wildlife is due to five key characteristics. The fourth characteristic is "the increased ecosystem productivity associated with anadromous salmon runs" (page 2-20, Section 2.3). Similar statements are made by Woolington (2009). How is this increase measured, and what is the baseline for the increase? I am sure the biologists that wrote about the increase are trying to convey the concept that the energy and marine-derived nutrients provided by salmonids is incorporated into the primary and secondary production in the terrestrial ecosystems in the Bristol Bay watersheds. I am not sure that such a statement considers the loss of energy and marine-derived nutrients as a result of commercial fishing. Is it possible that commercial harvest may decrease ecosystem productivity compared to productivity prior to pre-European (e.g., 200 hundred years ago) harvests? Perhaps it would be more accurate to delete the word "increase." On the surface, this might seem like a small edit but this edit is one of many edits needed to address, not only the existing conditions in the watersheds, but also the existing conditions relative to "pre-European conditions." My understanding of a Cumulative Impact Analysis is that it includes past assessments of ecosystem resources and functions as well as current and future conditions (see discussion of Cumulative Impacts in response to Question 11).

13. Pauly et al. (2000) and Libralato et al. (2008) address the energy impacts of fisheries. I would be interested to know if the impact of fisheries on marine-derived nutrients and energy available to the wildlife and terrestrial ecosystems in the Bristol Bay watersheds could be compared to the potential impact of the example mine on marine-derived nutrients and energy available to the watersheds. Is the potential impact of the mine small in relation to the impact of commercial fishing or very large compared to commercial fishing? Such information would be informative for determining acceptability of risks. It is possible that such a comparison could stimulate discussion of the possibility of compensatory mitigation for losses due to mining.

14. The assessment could be greatly improved if more of the linkages and pathways illustrated in the various Conceptual Models were addressed and if impacts on ecological parameters, such as community succession (down gradient, in the lake and on tailings and waste rock) and aquatic and upland structure and function, were addressed. For example, Site Reclamation is illustrated and highlighted as orange boxes in three places on Figure 3-2C (I'm not sure what the orange highlighting signifies, for there is no legend on this figure). Information on possible wildlife limiting factors (e.g., calving and nesting habitat) and plant communities in the watershed could improve the quality of Site Reclamation. A Reclamation Plan needs to address the likelihood that reclamation can be implemented and if so what benefits it might accrue through time. This type of information would likely result in a better risk assessment.

15. The discussion of wildlife species in Appendix C is very good but little of the insight provided in these descriptions of hunted or trapped species is reflected in the assessment of impact of potential mining practices on wildlife. I cannot help but wonder (i.e., mixed message) why Appendix C is so thick and so little of the good information in Appendix C is reflected in the assessment document. For example, the impact of noise and human presence related to mining and roads is addressed on page 54 (Appendix C). Such an impact on certain sensitive species could be equal to or greater than the loss of wildlife habitat in the mine footprint. Woolington (2009) indicates that the Red Dog Mine in Alaska has implemented certain measures that have reduced the impact of the haul road on wildlife. It would be good to know what these measures are and if such measures would be equally effective for a road relatively close to Anchorage.

    Will the proposed haul road to the mine be closed to the public and hunting? If so, the impact of the road may not be high. I can remember Val Geist saying that wildlife behave the way one teaches them to behave. Examples are deer in the streets of Banff Park during the daytime and big horn sheep and elk foraging along the Trans Canada Highway in the Park. The big horn sheep often stop traffic as people stop to observe them. Outside the Park, where deer and elk are hunted, one is less likely to see deer and elk along the highway and deer take on a more nocturnal existence.

16. As an arctic and sub arctic small-mammal wonk, I anticipate that any discussion of Alaskan ecosystems will include some discussion of the less charismatic fauna (small mammals and songbirds) and the functions they provide. Such discussion is given little attention in the assessment.

Question 11. Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

David A. Atkins, M.S.

According to the Assessment, cumulative risks result from the potential development of at least five additional prospects: Humble, Big Chunk, Groundhog, Sill, and 38 Zone. Exploiting these prospects would amount to development of a mining district (see discussion for Question 2 in regards to appropriateness of the mining scenario).

The Assessment quantifies the loss of stream lengths and wetland areas that potentially support salmon and resident fish from the development of these projects under a 'no-failure' scenario. The assessment is highly speculative given that mine development plans are not available for these prospects.

As with the Pebble scenario, it would be helpful to put this loss of resource in perspective in terms of the fish resources as a whole. It would also be helpful to describe any mitigation measures that are feasible to offset the impact of loss of streams and wetlands. Furthermore, it would be helpful to better understand the role these developments could have in further fragmenting salmon populations.

The following potential subsidiary impacts from development of a mining district of this scale should also be described in more detail or at least mentioned:

- The extensive road network required to support mines in the area and the attendant development associated with this network.
- The camps associated with the project, in migration of workers to the project areas, and the demand for resources to be imported from outside the area.
- Invasive species that may follow this scale of development.

Steve Buckley, M.S., CPG

The assessment does describe the potential for cumulative risks from the development of multiple mines in the area; however, the section is misleading in that it describes specific mine footprints and tailings disposal sites at these prospects where there is no information on the size or character of the potential future mine sites. The assessment does not describe the cumulative effects of mine development.

Courtney Carothers, Ph.D.

In general, the report suggests that effects from multiple mines would increase the prevalence and cumulative impacts of the risks described for the one-mine scenario. Again, for the cultural assessment, the conclusion is made that effects on humans would be primarily "direct and indirect loss of food sources" (7-15). As the number of large-scale mines increases in this region, the entire subsistence way of life could come under threat. This would be a much larger impact than lost food sources.

Dennis D. Dauble, Ph.D.

Individual risk is described in varying levels of detail with overall risk or effects considered to be largely additive. However, the relative magnitude of the effects of mining each ore deposit is difficult to discern. It is possible that one of the smaller ore sites could be developed within an acceptable risk scenario, but it is difficult to determine given that the assessment is largely built on potential impacts of the Pebble Mine. To put things in perspective (individually and cumulatively), there should be a discussion of habitat lost given each individual mine footprint, during normal operation (includes water treatment and withdrawal) and as a result of pollutant exposure. Also, Section 7.4.1 of the main report provides estimates of stream miles affected due to blockage and elimination, but provides nothing quantitative for other direct and indirect impacts of mine operation. The cumulative risk discussion in Chapter 7 could be expanded to link up with the conceptual model described in Chapter 3.

Gordon H. Reeves, Ph.D.

I found this chapter well done, even though the analysis was less extensive than what was done for the Pebble Mine. It is clear that multiple populations would be put at varying degrees of risk simultaneously if mine development occurs as is portrayed in this report. This certainly could compromise the "portfolio effect" (Schindler et al. 2010 Nature 465|3 June 2010|doi:10.1038/nature09060), which has maintained the long-term productivity of sockeye salmon in Bristol Bay.

Charles Wesley Slaughter, Ph.D.

Yes – but a qualified "yes." The Assessment appropriately outlines the probability of additional resource extraction projects beyond Pebble itself, and recognizes that additional resource opportunities (beyond the claims depicted in Figure 4-6), currently unknown or unverified, could become viable or desirable to some interests in the future. Section 7.4 summarizes many of the risks. However, the brief coverage (16 pages) accorded the entire subject of "cumulative risks" is **not** consonant with the very long-term, spatially dispersed (and presumably linked by transportation and communication corridors) impacts and risks of multiple mines (and associated infrastructure) in many different sectors of the Bristol Bay watershed.

John D. Stednick, Ph.D.

Cumulative risks can result from multiple risks (effects) from a single mine or individual risks from multiple mines. This chapter identified potential risks from proposed mine activities; without consideration of design standards or performance criteria, which is difficult without specific mine designs/plans. Environmental risks were weighted equally – a TSF failure as compared to a blocked culvert. The simple addition of stream length, as affected by various mine footprints, does not represent a cumulative risk.

The assessment does not identify any past activities, which is doubtful even in SW Alaska, and does not define a baseline condition for which to compare many individual or cumulative risks. There are many factors that could be included in the cumulative effects analysis from multiple mines. Human footprint of physical infrastructure: work camps, schools, community services, recreation, increased road access for visitors, sewage treatment facilities, urbanization effects on habitats and environment, transportation corridor, pipeline corridor, water resources usage, and regional and global climate change.

Roy A. Stein, Ph.D.

Cumulative Risks from Multiple Mines. Clearly, as amply demonstrated in the Environmental Risk Assessment, cumulative risks would be greater than those from just the Pebble Mine, even though these risks are difficult to quantify. Important points made in this section deal with the economies of scale that would benefit additional mines coming to the Bristol Bay watershed. After the first mine, new mines become more profitable simply because some of the infrastructure (roads, power, fuel pipelines, etc.) has already been provided, thus reducing cost outlays for the establishment of new mines. To me, this seems as quite an insidious process, for once the door is swung open for the first mine, then many more will follow owing to infrastructure considerations; with these additional mines come far greater cumulative environmental risks. Quantifying these risks would help the reader and the public understand what the ramifications of allowing one mine to begin operations might be. More text attempting to quantify these cumulative impacts would be useful and instructive.

William A. Stubblefield, Ph.D.

The potential for cumulative risks associated with the development of multiple mines in the Bristol Bay watershed is not treated with a great degree of detail. Although each of the potential stressors (e.g., water withdrawal, habitat illumination, road and stream crossings) are acknowledged and addressed, little quantitative consideration is given to the potential effects associated with development of multiple mines. This, however, is probably appropriate given the hypothetical nature of the single mine scenario and the potential for greater impacts associated with the development of multiple lines. Short of concluding that "failures at one mine could be bad and failures at multiple mines could be worse," little else could be concluded. It is noted that the multiple mines scenario leads to multiple tailings impoundments, more roads and culverts, increased discharge potential of contaminated waters and increased habitat loss and reduction of water resources and all of these lead to potentially greater environmental injury as a result of failures.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not appropriately describe the potential for cumulative risks from multiple mines. In fact, the assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about estimating and expressing the magnitude of risks and what is required to appropriately describe the potential for cumulative risks from multiple mines.

The cumulative assessment is very conceptual at best, as there are no specific proposals from any of the other potential resource areas. Cumulative impacts can only be evaluated once further details about other potential mines and their plans are available. At this time, this section can at best be seen as speculation.

It is impossible to improve this part of the assessment with the information on mine development currently available; it can only be done when further information is published by the various mining companies.

Phyllis K. Weber Scannell, Ph.D.

There are two issues that should be considered: cumulative effects from a single mine and cumulative effects from multiple mines. Cumulative effects from a single mine might include aquatic habitat degradation from non-point sources, including run-off from exposed mineralized rock, seepage from the tailings impoundment, contaminated dust, noise, and other forms of disturbance.

Cumulative effects from multiple mines are difficult to predict because there are too many unknowns. It is frequently to the advantage of a mining company to take advantage of existing infrastructure, without building new camps, new mills, etc. It is also possible to use an old mine pit for tailings or waste rock disposal from a new site; however, none of these features can be determined until there is sufficient exploration to determine if mining is feasible, to characterize the deposit, and to develop a detailed mine plan. To date, there is not sufficient information to predict cumulative effects from multiple mines.

Paul Whitney, Ph.D.

<u>Need to Address Past Impacts.</u> EPA's guidance for reviewing cumulative impact analyses (EPA 1999 – most recent guidance on EPA's website) asks that <u>past</u>, present and reasonably foreseeable actions be considered. The assessment's coverage of cumulative risks from multiple mines certainly addresses "reasonably foreseeable" mines. Not addressed in the analysis is past impact(s) and how such impact(s) might be additive to current and foreseeable impacts. As commented above, commercial fisheries remove a lot of the salmon (up to 70% - over 10 million fish) annually from the drainages associated with the mine. The continual annual reduction, or loss of energy and nutrients that might otherwise return to the ecosystems, should be considered a past impact as part of the cumulative impact analysis.

I have prepared/managed cumulative impact analyses of fish and wildlife for a relatively small (e.g., a 200-acre aggregate mine) and a relatively large 7,100-acre coal mine in Washington. A cumulative impact analysis of past, present, and future fish and wildlife losses for the coal mine expansion in a large watershed indicated cumulative impacts of the expansion were less than one percent of past mining, agriculture, urban and forest activities in the watershed. In addition, the cumulative loss could be fully mitigated by compensatory restoration. I would be interested to know what the estimated fish and wildlife loss is due to the example copper mine in comparison to the loss related to the commercial fishery. In addition, I would be interested to know if potential fish and wildlife losses due to mining could be fully mitigated. If the watershed is pristine or nearly pristine, the opportunity for compensatory mitigation may be low. If the past impact of the commercial fishery is large and the watersheds are not pristine, there may be opportunities. There is not much degraded habitat that could be improved by a mitigation plan. If such a cumulative impact analysis were conducted, it may stimulate conversation about reducing commercial fishing to compensate for impact losses due to mining.

Question 12. Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

David A. Atkins, M.S.

The Assessment describes what is considered to be conventional 'good' mining practice, but does not adequately describe and assess mitigation measures that could be required by the permitting and regulatory process. A thorough analysis of possible mitigation measures as employed for other mining projects and the likelihood that they could be successful in this environment would be necessary.

It is highly likely that for mines located in the Bristol Bay watershed, conventional engineering practices would not be sufficient. Therefore, it is important to consider mitigation on numerous fronts when determining the viability of the project. A section on innovative and state-of-the-art approaches for both mitigation and construction of mine facilities would be helpful to better understand if risks can be minimized or eliminated given sufficient funds.

Under the no-failure scenario, the footprint of the mine (open pit, block-cave subsidence zone, waste rock and tailings areas) will by necessity destroy habitat. There may be ways to create equivalent habitat to compensate for lost habitat in areas within the watershed that are currently not productive for fish. This form of mitigation may work for resident fish, but it is unclear if it would work for anadromous fish that return to very specific locations to spawn.

It is also becoming common practice to offset impacts from project development with preservation of equivalent habitat areas that are also at risk from development (http://bbop.forest-trends.org/). It is unclear if this is a feasible consideration for this project as this could involve allowing one development (e.g., Pebble), while potentially taking away the development rights of others (presumably for proper compensation).

Steve Buckley, M.S., CPG

There are many reasonable mitigation measures that could reduce the risks and impacts beyond those described in the assessment. Some of these are contained in the Appendices and referenced therein but not discussed in detail or described in the assessment. It is beyond the time constraints provided in this review to develop an exhaustive research list of these potential mitigation measures; however, EPA could include measures designed to: reduce the mine footprint and limit the number of potentially affected watersheds; reduce, isolate, or eliminate the amount of potentially acid generating waste; provide secondary containment measures for all pipeline corridors; and use natural streambed arch culverts and bridges at fish bearing stream crossings.

Courtney Carothers, Ph.D.

While I do not have knowledge of mitigation measures, a more thorough discussion of mitigation measures could be included. Even if mitigation measures are largely deemed to be ineffective in this case, they should be presented and evaluated as such.

Dennis D. Dauble, Ph.D.

Potential mitigation measures are well described in Appendix I. I have no suggestions for additional measures. Implementation of mitigation measures is entirely dependent on the regulatory framework for operations and the oversight and monitoring practices that would be mandated as a condition of the mining activity. Thus, some discussion of how/which mitigation practices would be most applicable in the Bristol Bay watershed (and limitations thereof), given constraints and characteristics of local hydrology and geology, is warranted.

Gordon H. Reeves, Ph.D.

I identified one potential mitigation for culverts – the use of open arch types that are at least one bankfull width in size. As described in my response to Question 7, this could reduce many of the potential impacts raised by the authors.

Charles Wesley Slaughter, Ph.D.

If it is assumed that the PLP project, or some similar development, were to go forward, I cannot suggest mitigation measures beyond those discussed above. Since a major concern for salmonids – perhaps THE major concern – is with consequences of the transportation corridor, simply having the mine without the roads/pipelines would alleviate much potential risk. However, there is presumably no practical, economically feasible way to not have the transportation corridor; air transport of all materials to and from the site might technically be possible, but would not be economically feasible.

John D. Stednick, Ph.D.

The purpose of this assessment is not to identify mitigation measures. This suggests that things can be fixed by mitigation. Risks were identified for a variety of situations, and the preventative measures would better address the mining impacts. Mitigation measures are also a mining cost that needs to be determined by the mining company and compliance with state and Federal regulatory authorities.

Roy A. Stein, Ph.D.

Mitigation: Complete Tailings Storage Facility (TSF) Failure. In some ways, some of the failures reviewed herein are not really subject to mitigation. For example, if a Tailings Storage Facility (TSF) completely fails, options for mitigation become limited very quickly. With a complete failure, it is "game over", with toxic sediments flowing into the Nushagak River all the way to Bristol Bay, thereby destroying the entirety of salmonid spawning habitat in this river by redirecting the channel and inundating the gravel/cobble steam bed with sediment (meters in depth). Mitigation under these circumstances is impossible, in my view. Given this scenario, I was surprised that the impacts were only assessed 30 km downstream of the TSF failure; is this realistic? I think not, given what we know of other mines.

The amount of text dedicated to a TSF failure is large (36 pages) as compared to other failures. I suggest this section be shortened to bring it more in line with other sections. Briefly summarizing impacts would focus the text and help the reader appreciate what it would mean to have a TSF failure without having to wade through so much text.

Dry Stacking Mine Tailings: Appendix I, page 9. Given the horrific impact of a TSF dam failure, should mine operators consider a relatively new technique incorporating "paste tailings technology"? Here, tailings are thickened by water removal (down to 20% water) and filtering;

tailings are then dry stacked onto a lined disposal site. These stacks "have a lower potential for structural failure and environmental impacts" (Martin et al. 2002). I would encourage the authors to argue for this substitute for the more traditional TSF for this solves at least two problems: 1) eliminates the possibility of a TSF failure (a huge gain!) and 2) reduces the amount of monitoring and maintenance of the waste tailings "In Perpetuity" (another major gain). Finally, what does "Best Management Practices" have to say about these two approaches to the storage of tailings waste?

Mitigation: Partial TSF Failure. If a TSF partially fails or is discovered beginning to fail, then I believe mine operators have a chance to save the dam and thereby protect the river, but only if: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response are in place, 2) the necessary equipment (my presumption here is that heavy, earth-moving equipment would be required), materials, and supplies are onsite near the facility, and 3) trained personnel (meaning that they have practiced these repair SOPs in the preparation for such an event) are available for immediate action. One might argue that these procedures are more proactive than mitigating and I would agree, reflecting the near impossibility of invoking any mitigation measures associated with TSF failure.

Dredging: Post TSF Failure. In the text (pages 6-1 to 6-2), a reference is made to dredging materials out of the river post spill. I can't imagine this would mitigate any losses of spawning substrate for salmon. Indeed, because only 5% fines in gravel substrates compromise salmon reproductive success (and perhaps even selection of these areas for spawning in the first place), removal of meters of sediment with a dredge doesn't seem to be a solution. Whereas dredging might, in a best-case scenario, reduce the time to recovery of the substrate, I don't believe it will hasten recovery significantly. Dredging also serves to bring toxic sediments up into the water column perhaps compromising all organisms in the system. By not dredging, we allow the natural system to recover, which, in my view, would be preferable to any sort of "dredging mitigation". Some reflection by the authors on this issue would be valuable.

Mitigation: Pipeline Failure. With automatic shut-off valves stationed along all four pipelines, we would expect to know precisely just how much effluent will be spilled during any single event. With this information in hand, mine operators can easily anticipate spill size, toxicant characteristics and thereby judge what equipment, materials, and supplies would be necessary for mitigating any spill. As with the TSF failure, mine operators should have in place: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response, 2) the necessary equipment, materials, and supplies onsite near the pipeline (given the length of the road, these items should be cached at several locations along the road, such that response time is minimized), and 3) trained personnel (meaning that they have practiced these mitigation SOPs in the preparation for such an event) are available for immediate action. Shouldn't pipes be double-walled? Again, what would "Best Mining Practices" say in this context?

Mitigation: Failure of Water and Leachate Collection. This failure differs from TSF and pipeline failure, where failures are more akin to catastrophic, for here failure is somewhat more gradual in coming (my guess is). Proactive vigilance is the watch phrase here where continual, careful monitoring will indicate when failure begins. Because the "spill potential" is relatively small (certainly compared to a TSF failure), less urgency is required on the part of mine operators. However, as pointed out previously, just because the potential is small, over time the impacts could be great. Hence, the mitigation undertaken with water and leachate collections would require (one would hope) just the tweaking of the collection system in place to eliminate leakage through time. Again, personnel trained in how to respond to these gradual increases in water and leachate leaks are required to stay ahead of this issue, thus preventing any toxic materials from flowing downstream into the Nushagak and Kvichak rivers.

William A. Stubblefield, Ph.D.

I'm sure there are number of technological/engineering measures that could be implemented to reduce the potential for environmental injury associated with development of mining in the Bristol Bay watershed. The development of this *a priori* risk assessment provides useful information in identifying were potential risks may exist and should provide mine development professionals with the degree of guidance about the types of risks and potential consequences of mine activity failures. Perhaps by recognizing the magnitude of adverse consequences associated with potential failures, steps can be taken to implement safety measures early in the planning process that would render mine development more acceptable. In addition, using the assessment to define areas of uncertainty my provide direction for future research that would be beneficial for the project. Again, because of the lack of detail associated with the hypothetical mine scenario, it is impossible to estimate the likelihood of success of any mine control activities.

Dirk van Zyl, Ph.D., P.E.

Yes, there are reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described and incorporated by the EPA in the assessment. There are a host of measures that are not addressed in the assessment and lists of these are identified below under the headings of regulatory and engineering. This list is by no means exhaustive.

While the EPA Assessment presents a series of potential mitigation measures in the main report, the majority were rejected. Appendix J to the report also includes a generic discussion of mitigation measures. The Main Report does not address the application or implications of these in any project specific details, e.g. compensatory mitigation for wetlands, streams and other aquatic resources.

Multi-stakeholder engagement processes, such as Failure Mode and Effects Analysis, can be used to further expand on these mitigation measures. It is recommended that EPA recognize these and potentially other measures that may be proposed in the public comments and make a serious effort in including the potential effects of these on failure likelihoods, consequences and risk magnitudes. It is an important aspect of improving on the range of potential outcomes.

Regulatory. The EPA Assessment neglects the typical outcomes resulting from the permitting and regulatory processes for new mines, where permit stipulations may require specific actions resulting from discussions, public comments and regulatory frameworks. The following is a partial list of these:

- Section 404 of the CWA (See discussion under Question 3 above).
- Permitting stipulations and requirements for monitoring. Using permit stipulations for monitoring can reduce a large number of the consequences identified in the report. For example, the consequences associated with blocked culverts, etc. can be significantly reduced by permit monitoring requirements and subsequent enforcement.
- Financial assurance will be required for mine closure. Financial assurance can be a very beneficial tool during operations, premature closures, mine closure, as well as post-closure monitoring and maintenance. Experience gained during operations can help develop the closure and post-closure financial assurance requirements.

Engineering. A number of engineering options are mentioned in the report but discounted in many cases. Many of these engineering mitigations are currently used in the industry. The following may repeat a number of those mentioned in the report:

- Redundancy, e.g. additional embankments may be considered downstream of the TSF to contain tailings and supernatant that may be transported as a result of TMF failure. While this may result in a larger local surface impact, it will protect downstream waters in the case of a failure resulting in tailings discharge.
- Further processing of tailings to remove the remaining sulfides.
- Tailings management options other than slurry deposition, such as production and management of filter cake.
- Waste rock management options to reduce releases during operations, e.g. addition of lime to the PAG rock.
- High standards implemented for road design, construction, monitoring and maintenance.
- Double containment of all pipes containing concentrate and other materials. This is already required under the International Cyanide Code for all pipelines containing cyanide solutions.

The likelihood of success of these proposed and other potential mitigation measures can be evaluated by considering their impacts on the overall project. A range of alternative project technical alternatives and facility-siting locations will have to be developed instead of using only the hypothetical scenario.

Phyllis K. Weber Scannell, Ph.D.

There are many avoidance or mitigation measures that would be implemented to reduce or minimize mining risks. I have described some possible approaches when answering the previous questions. To summarize:

The two most important questions for reducing or minimizing mining risks are:

- Can a mine in this area be designed for closure?
- Is it acceptable to develop and operate a mine that will require essentially perpetual treatment?

Specific Measures that can be taken to minimize risk include:

Limiting metals contamination and acid drainage:

- Design the mine pit to limit oxidation on pit walls. Where feasible, conduct concurrent reclamation.
- Develop plans for classification and storage of waste rock, lower grade ore, overburden, and high grade ore.
- Develop and maintain tailings storage facilities with fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized. Consider alternate methods for tailings disposal (dry stack following sulfide removal, etc.).
- Implement concurrent reclamation of disturbed areas, including stripped areas and mine pits.
- Collect and treat point and non-point source water.

- Design and implement plans for the quantity and timing of discharges of treated water; especially if the treated water is high in total dissolved solids. Monitor ground water, seepage water, and surface water.
- Design system for collection and bypass of clean water and collection and diversion of contaminated water to a water treatment system.
- Require stations for truck wheel washing.

Protection of Fish Habitat:

- Review all in-stream activities in waters important to the spawning, rearing, or migration of anadromous and resident fish.
- Design and implement a biomonitoring program.
- Review every road crossing of fish bearing waters to ensure free passage of fish.

Possible Measures to Limit Effects to Wildlife:

- At the planning stages, design aspects of the project to create or enhance wetland and aquatic habitats for fish, bird, and wildlife species.
- Limit truck traffic on the haul road during migrations.
- Incinerate all kitchen waste.
- Educate workers on bear (or other wildlife) safety.
- Limit air traffic and noise during critical times of the year.

Paul Whitney, Ph.D.

Comments on Mitigation. The key word here is "reasonable." What is reasonable to a person not involved in mining on a day to day basis will likely not be reasonable to a mining company executive or mining engineer. The likelihood that "reasonable" means different things to different people is exacerbated by the mixed messages regarding "best" mining practices (e.g., page ES-10, five lines from the bottom) versus "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). As mentioned above, both of these statements can't be accurate. For purposes of this discussion, I am assuming that there are many more mining practices that could be proposed to address many of the uncertainties mentioned in the assessment. First of all, most of the mitigation measures mentioned in the assessment provide one line of protection and I suspect there are many types of redundant mitigation that could be implemented. Redundant protection such as: double-walled pipes in all sections that cross floodplains (above and below grade); poly liner/vegetated caps to soak up and capture run off water before it contacts waste rock; redundant clay, glacial till (waste360.com/mag/waste_landfills_glacial_till); poly liners; and secondary liquid collection systems.

I appreciate the assessment's discussion of the potential difficulties of using poly liners, but the discussion might benefit from a review of Koerner et al. (2005) that provides another perspective on the life of HDPE liners. The relationship of liner life to temperature is presented in their Table 2 and a summary in the text indicates that covered liners have a "half life of 446 years at 20 degrees Centigrade." This is a lot different from the 20 to 30 year estimate of service life cited in the assessment on page 4-11(last para). Appendix I does cite a 2011 version of the Koerner et al. (2005) paper and appears to misquote it (page 9, last para, last full sentence). The Koerner et al. (2005) paper estimates a "halflife of 446 years" not a "lifetime" of 446 years, as cited in Appendix I. Perhaps Koerner updated his 2005 estimate in the 2011 version.

I assume a mining engineer (if asked) could design a series of smaller impoundments or innovative lined impoundments that could avoid a lot of the problems cited in the assessment. The trade-off might be increased loss of natural resources due to a larger footprint and increased construction cost, but the risk cited in the assessment and the risk of a catastrophic failure might be greatly lowered. I would be interested to know what THE BEST mining practices are. If the mitigation measures mentioned in Appendix I are, in fact, the best, it should be so stated and taken into consideration in the assessment. For example, page 4-21 of the assessment indicates the TSF would be unlined and not have an impermeable barrier between the tailings and groundwater. Appendix I, page 9 indicates TSFs can be lined if problems are expected. There is a lot of good information in the Koerner et al. (2005) paper and Appendix I. It seems the types of mitigation measures in Appendix I could be better captured in the main report.

Compensatory mitigation and reclamation are briefly mentioned in the assessment. A more detailed discussion of the opportunities and feasibility of reclamation and compensatory mitigation might reduce the likelihood of potential impacts of the example mine plan (see response to Question 3).

Question 13. Does the assessment identify and evaluate the uncertainties associated with the identified risks?

David A. Atkins, M.S.

The Assessment states: the 'range of failures is wide, and the probability of occurrence of any of them cannot be estimated from available data.' Uncertainty is addressed throughout the report, typically with a qualitative discussion. There is a high degree of uncertainty with respect to how the mine would be developed, operated and closed, as well as how any impacts would be mitigated. This large uncertainty makes assessing risk difficult.

Steve Buckley, M.S., CPG

The assessment identifies some of the uncertainties associated with the identified risks but does not evaluate these in great detail.

Courtney Carothers, Ph.D.

The report includes specific sub-sections to discuss uncertainties for the risks associated with habitat modification (Section 5.2.4), pollutants (5.3.4), and water collection and treatment failure (6.3.4). Uncertainties related to abundance and distribution of fish in the watershed draining the mine site, road and stream crossings, salmon-mediated effects on wildlife, salmon-mediated effects on human welfare and Alaska Native cultures, tailings dam failure, pipeline failure, and road and culvert failures are not discussed in separate sections; however, several uncertainties related to these risks are noted throughout the report, and in summary sections (Sections 8.5 and 8.6).

The "sensitivity relative to overall results" of the key assumptions and uncertainties presented in Table 4.8 in Appendix E (pp. 193-195) would be a helpful model to employ in the main report. For non-experts in the technical dimensions of mine construction and operation, uncertainty rankings would be useful. For example, "We are 'highly uncertain' about the accuracy of these predictions given this unknown factor," or "We expect this uncertainty has a negligible effect on the model we employ to calculate this risk."

Dennis D. Dauble, Ph.D.

The most likely scenarios and probabilities of failure are described based on assumptions of project size and magnitude. For the most part, estimated risks are conservative (i.e., effects are stated as "likely" if no further information is available). A weakness of Integrated Risk Characterization (Chapter 8 of the main report) is having a long list of identified uncertainties, which leads one to speculate, "so what do we know?" Not being familiar with the formal risk assessment process, it appears this "assessment" (which is loosely based on a risk assessment framework), falls short of providing something with any degree of certainty.

Gordon H. Reeves, Ph.D.

Uncertainties and limitations are explicitly identified and acknowledged for topics that I am familiar with (fish and aquatic ecology and fish habitat) throughout the report. These are summarized succinctly and clearly and the consequences to the findings are articulated.

Charles Wesley Slaughter, Ph.D.

Yes. The authors fairly attempt (pp. ES-24-26, and in each chapter) to note the various uncertainties and assumptions incorporated into the Assessment. Sections 8.5 and 8.6 briefly summarize those uncertainties. A question remains concerning the "uncertainties" associated with assigning probabilities to various failure scenarios; I remain unconvinced that those probabilities have real meaning or significance for decision-making (see response to Question 5, above).

John D. Stednick, Ph.D.

The uncertainties are presented adequately.

Roy A. Stein, Ph.D.

Uncertainties. I think that the Environmental Risk Assessment did a nice job of identifying uncertainties surrounding this presentation, but a relatively poor job of quantifying them (at least partially due to a lack of information). As a consequence, I found this section more than disconcerting. Certainly, the authors have worked hard to present an accurate portrayal of the impact of a large-scale open pit mine in the watershed of Bristol Bay. Even so, upon review of the list of uncertainties with regard to this effort (pages 8-10 to 8-13), I conclude that we know little of what the impact of this mine will be in any quantitative sense. Clearly, from the Environmental Risk Assessment, we do know qualitatively what is likely to occur when a mine of this size and type will be put into operation in this environment.

However, from the list of uncertainties, we are operating at the outside edge (and beyond in many cases) of the semi-predictive models used in anticipating the impacts of the mine footprint, the routine operations of the mine, and the impacts of failures of TSF, pipelines, and water/leachate collections on extant salmon populations. And our knowledge of the baseline populations of the seven species of salmonids is no better, for we do not know the size, diversity, distribution, or vital rates (i.e., recruitment, growth, and survival across life stage) of these fishes.

Couple these two sets of uncertainty and the prognosis outlined in the report is suspect, at the very least, and somewhat anticipatory at best (I cannot bring myself to use the word "predictive"). I fully realize that these are the cards the authors were dealt (I do applaud the authors for making the best of an information-poor environment), but it seems to me that we are on tenuous ground when we attempt to predict the impact of the Pebble Mine on salmon, associated wildlife, and Native Alaskan cultures in the Bristol Bay Watershed.

William A. Stubblefield, Ph.D.

The risk assessment attempts to identify and evaluate the uncertainties associated with each of the recognized potential risks. The authors have, for the most part, successfully identified a number of uncertainties that may affect the accuracy and conclusions of the risk assessment. Clearly, this information should provide a basis for prospective mine planners and regulatory authorities to focus their efforts to minimize potential environmental risks. In some cases the uncertainties identified are probably best addressed through the development of additional data and this should guide future research efforts undertaken prior to mine development and operation.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about risk. Uncertainties are identified and evaluated for the likelihoods of occurrence and in some cases for the consequences. However, because the magnitudes of the risks are not expressed, their uncertainties are also not explicitly expressed.

The report identifies uncertainties in a number of sections, including in Chapter 8. In many cases, these uncertainties are expressed in qualitative terms and are not quantified. The biggest uncertainty/variability in the evaluation of a hypothetical project is associated with the potential range of design features, waste management options and operational details that could be included. This was completely overlooked in the analysis by assuming a specific design for the hypothetical mine. The failure likelihoods and consequences on salmonid fish are very dependent on the assumptions for the hypothetical mine. These uncertainties are neither clearly identified nor included in the evaluations. This is a major shortcoming of the present analysis.

Phyllis K. Weber Scannell, Ph.D.

The important features of the Environmental Assessment are to describe the fish, wildlife, and human use of the subject area and to define possible risks from development of a large porphyry copper mine. There are many uncertainties associated with the identified risks and most were identified in the document. The document could be strengthened by putting a greater emphasis on sources of contamination (such as mine seepage, poorly designed collection systems, exposed pit walls, etc.) in relation to the permeability of the soils.

The 5th bullet on page 8-11 outlines important uncertainties for protecting fish species. These uncertainties include life-stage-specific sensitivities to temperature, habitat structure, prey availability, and sublethal toxicities. These factors must be considered should a mining project go forward.

The 6th bullet on this page discusses the preliminary nature of leaching test data. These tests must be sufficiently comprehensive to predict both short term and long term water quality from all sources, including PAG and NAG waste rock, pit walls, and pyritic tailings.

Paul Whitney, Ph.D.

Uncertainty summary. The discussion of uncertainties in the assessment is, in most cases, appropriate. It seems that one could use these discussions as a scope for additional work needed prior to an assessment that would properly assess risk of the example mine. As the uncertainty discussion appears in the assessment, this reader wonders what to make of it. There is a lot of uncertainty in this world that we find acceptable; the ultimate goal seems to determine if the cumulative uncertainty is acceptable or not. Such an evaluation remains to be made and I'm not sure how it could be made based on the level of information presented in the assessment and the current state of the uncertainty discussions.

The summaries of uncertainty included in Sections 8.5 and 8.6 could be improved if some sort of realistic and useful conclusion(s) could be presented. The Section 8.6 summary seems to "pile on" uncertainties, rather than summarize the uncertainties in the assessment. While piling on is informative, it is not the sort of summary I was looking for. Conclusions in the Section 8.5 summary of conclusions remind us that the effects of mining on fish populations could not be quantified and, as a substitute, the effects on habitat were used as a surrogate. So we are left with an estimate of 87.5 to 141.4 km of streams that would be removed and this would cause an adverse effect. Based on this very general risk conclusion, we learn that "In summary, it is unlikely that there would be significant loss of salmon subsistent resources related to the mine footprint" (page 5-77, last paragraph). First, it's not clear how this conclusion was reached. Second, if such a conclusion was possible for subsistent resources based on the data available, why couldn't such a conclusion be reached for sport and commercial fisheries? Third, does it follow that no significant loss to salmon subsistence resources would result in no significant loss to wildlife that utilize this resource? If so, such an indirect analysis is not informative regarding an environmental assessment for the example mine. Alternatively, a direct assessment of the loss of habitat using habitat-based population models for both fish and wildlife would be much more informative.

Adaptive Management. Holling (1978) in his Adaptive Environmental Assessment and Management book discusses political uncertainty and how adaptive management might be able to address the issue. Considering that the mine being proposed is a multi-century system, it's poignant to realize that Alaska was owned by Russia about 150 years ago and Oregon was being claimed by the Spanish about 200 years ago.

Adaptive management is a tool designed to deal with uncertainties in risk evaluations (Ruhl and Fischmann 2010). If implemented properly, with testable hypotheses of risk, adaptive management may be something to consider for the example mine. My experience with adaptive management is that adequate funds are seldom allocated to learn by doing, to test hypotheses and to implement new management if hypotheses are not met. Formalizing financial instruments to ensure that funds are available is equally difficult to negotiate. Nonetheless, I agree with Ruhl and Fischmann that the theory of adaptive management is sound and may be the only way to deal with uncertainties such as climate change. Considering the number of uncertainties identified in the assessment, for the scope of work to clearly state hypotheses, to address the uncertainties, to fund studies to test the hypotheses, and to fund alternative management if hypotheses are not met is cumulatively daunting. For example, there are about 50 state variables in each of the Site Model Figures (3-2A, B, C and D). All totaled, that's about 200 (50 x 4 figures) state variables for salmon alone. Considering there are 100s more species, that's about 20,000 (200 x 100 species) state variables. Then there are fluxes/linkages between the state variables and that is another 20,000 fluxes/linkages that should be monitored. For adaptive management to work, clear goals and hypotheses to assess whether observed data meet the goals should be stated for approximately 40,000 variables and linkages. Then there is the task of defining the monitoring methods and statistics to determine whether or not goals for the variables and linkages are being met. I acknowledge that there are probably ways to trim down the monitoring effort, but one can start to imagine the enormity of implementing a monitoring plan for adaptive management. Then there is also what to do if goals are not realized. I am not aware of any alternative to adaptive management other than contingency planning which often lacks the "learn by doing" feature of adaptive management.

Important wordsmithing. So many of the uncertainty evaluations make statements about certain parameters that "could not be predicted" (page ES-20, para 4); "could not be quantified" (e.g., page 6-11, second full para); or are "unpredictable" (page 5-44, para, line 8). These are just a few of many examples. It would be more acceptable, at least to me, to state that estimates were not included in the assessment. This type of wording occurs in some parts of the assessment and might be more accurate.

Vague wording. The assessment includes a lot language that seems vague, at least to me. The list is long but includes: "highly pure water"; "other ecological responses"; "key wildlife"; "essential wildlife"; "overall ecosystem functioning"; "serious population-level consequences"; "different thermal characteristics"; "could be locally significant"; and "very long time." Lackey (2001) acknowledges the need for scientists to communicate with the public using normative science but expresses concerns that normative descriptors such as ecosystem health are subject to wide interpretation. He suggests that the most direct alternative to using normative science is to simply and clearly describe what is being discussed. The assessment would benefit if the normative type words used above (any many more) were quantified with estimates, a range or some type of measureable or testable parameter.

Question 14. Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

David A. Atkins, M.S.

Long-term risks from development of an open pit have not been characterized. It is difficult to predict the chemistry of the lake that will form in the open pit, but there is some potential that water quality will be poor, which may be exacerbated by pit backfilling with waste rock. The pit lake could impact waterfowl and may have some impact on groundwater if there is outflow when the lake reaches an equilibrium level.

Steve Buckley, M.S., CPG

None.

Courtney Carothers, Ph.D.

All other comments are contained below, in Specific Observations.

Dennis D. Dauble, Ph.D.

Based on public comments and discussions that took place by panel members in Anchorage August 7-9 of this year, this report confuses in both intent and approach. Is the intent of EPA's assessment to characterize potential impacts to the Bristol Bay watershed (title) or does it address a more defined portion of the Nushagak River and Kvichak River watersheds (objective statement)? Was the approach an "assessment" (a fairly broad term) or an "ecological risk assessment" (suggests a specific scientific framework was applied to the risk/effects analyses)? These shortcomings should be addressed in the final assessment document.

Gordon H. Reeves, Ph.D.

The major issue that was not considered in the assessment was the potential impact of climate change, particularly regarding the form and timing of precipitation. Admittedly, there is uncertainty about the magnitude of changes that will result from climate change, which makes it difficult to consider. However, the potential consequences of climate changes on such topics as tailing site facilities, water availability, and culvert failure seem appropriate. It will also be important to consider potential impacts of climate change so their signal can be distinguished from potential mine impacts during any monitoring that occurs.

Charles Wesley Slaughter, Ph.D.

I would simply re-emphasize that a truly comprehensive assessment of the potential consequences of a large-scale mineral extraction project, be it the "hypothetical" Pebble-like project or a different endeavor, should fully consider both the immediate project-specific impacts, and the long-term watershed-wide consequences of "ancillary" developments – such as other mines, which might become economic once the primary project's infrastructure is in place. There should be full recognition of the irreversible nature of such developments, and of the potential and limitations of possible reclamation or mitigation measures for the full suite of resources and ecosystem "services" involved, both short-term and long-term.

John D. Stednick, Ph.D.

There are several references to streamflow measurements that would be especially helpful to better characterize the site. The US Geological Survey has some streamflow gauging stations and precipitation records that would complement the analysis. Annual precipitation values were derived apparently from a computer model used to analyze global climate change at University of Alaska Fairbanks. How do these data compare to field measurements? The prediction of a 10, 50, 100, or larger event using a short-term precipitation record, results in a larger error term on the predicted streamflow. How common is the occurrence of rain on snow (ROS) streamflow events?

Dust production and transport: A variety of mining processes will generate dust. What are the wind patterns, chemical composition, and opportunity to land in surface waters or wetland areas? What potential is there for metal or toxin transport? Overburden removal will require explosives that leave nitrate, ammonia, and often sulfur in the air. What about this transport? Or rain out?

The literature cited is often dated or lacking. The technical review panel has proposed numerous references that can be used to strengthen the document.

Roy A. Stein, Ph.D.

- **IN PERPETUITY**

  Sustainable Salmon vs. One-Time Mine. Some irony exists as one considers the trade-off between salmon and this mining operation (and make no mistake, we cannot have both mining and productive salmon stocks in the Bristol Bay watershed). We are trading sustainable salmon stocks that, with science-driven management, rigorous regulatory oversight, and limited exploitation, should provide salmon literally 1000s of years into the future against the development of a mine that will provide minerals in the relative short term (within 25 to 78 years). As a result of the mining operation, the government (and likely it will be the state or Federal government) will be saddled with a 1000 years (at a minimum, based on the assessment) of monitoring and maintenance of this closed-mine site.

- **MINERAL NEEDS**

  Strategic Needs. I was surprised that no section of the Environmental Risk Assessment included any justification for why copper (does mining copper fulfill a strategic need for the United States; most all sites I researched do not list copper as a strategic mineral for our country), gold, molybdenum, and some additional rare earth elements were needed within the context of our economy. Are other sources available? Are these specific elements in short supply? Are they required for the United States to compete in worldwide markets regarding cell phones, other electronic devices, or solar panels? For example, rhenium is used in the aviation industry and some web sites suggest it is critical to our defense industry. Some justification would have helped me understand this huge undertaking.

- **ORGANIZATIONAL ISSUES**

  Page 5-59. I struggled throughout the document with organizational issues. As I read more and more text, I had the sense that I had read these facts or these perspectives previously. I mention this above but it is here on page 5-59 that the issue is nicely summarized. Note the text in the last paragraph of the page, where it discusses all of the important issues associated with roads and stream crossings. My suggestion would be that these sections (for every topic) be combined such that one section would exist for Roads, one for the Pipelines, etc. In so doing, the reader can capture all of the relevant information about a specific aspect of the mine in a single section of the report. I believe this would improve impact, readability, and shorten the report substantially (and also serve to reduce what seems to be a fair amount of redundancy).

Pages 6-10 to 6-11. These pages reflect another example of redundancy. Text to this point discussed and reviewed just how long we might expect the fine sediments to persist in rivers and streams post tailings dam failure. Yet, here again, on pages 6-10 to 6-11, these numbers are reiterated. Combining these sections would help the reader and reduce redundancy.

Section 6.3, Pages 6-36 to 6-42. Not to beat a dead horse, but in this section, nearly all of the citations to tables and figures are to those tables and figures that are found in sections of the report other than Section 6. This organizational scheme is what makes the report cumbersome to read and follow the logic and the argument.

Literature Cited

Kovach, Ryan P., Anthony J. Gharrett, and David A. Tallmon. 2012. Genetic change for earlier migration timing in a pink salmon population. Proceedings of the Royal Society B published online, July 11, 2012, doi: 10.1098/rspb.2012.1158

William A. Stubblefield, Ph.D.

I have no additional comments to add at this time.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment mentions twice that "interactions with regional stakeholders" and interactions with members of the Intergovernmental Technical Team were used to refine the analysis, etc. (p. ES-2 and p. 3-6). A robust stakeholder process includes careful documentation of the stakeholders identified during the project (which may include stakeholder mapping), records of meetings (attendee lists, meeting notes, etc.), resolution of differences, etc. The EPA Assessment does not contain any references to any such materials, which implies to me that the stakeholder process was informal and not robust.

Phyllis K. Weber Scannell, Ph.D.

At present, Pebble remains a prospect and there is no plan of operations for the mine. Should the project move forward to development of a mine, it will be necessary to develop an in-depth mining plan of operations. The mining plan should include the following:

- Transportation – of equipment and personnel and for shipping ore. Transportation of ore, including loading facilities, wheel washing, and other measures to prevent ore spillage and contamination.
- Siting of mine facilities, including tailings ponds, waste rock storage areas, concentrate storage area, bypass systems for clean water, and collection systems for contaminated water.
- Mill operations, including a description of the process for concentrating ore.
- Chemical and fuel storage and Spill Prevention and Contingency Plans.
- Personnel housing, including handling of domestic waste (sewage, garbage).

- Water treatment plant. Processes that will be used, anticipated concentrations of metals and TDS, anticipated discharge volumes, and predicted mass loadings.
- Monitoring plans for seepage from tailings ponds, waste rock storage areas, etc. Monitoring likely will include a series of wells and possibly, a pump-back system.
- Predictions for acid rock generation and measures that will be put in place during mining to minimize future seepage from the mine site.
- Plans for concurrent reclamation and future closure of the mine.
- Specifications for sufficient bonding to provide site stabilization and water treatment in the event of a premature or temporary shut-down and reclamation at closure.

After the Mine Plan of Operations is developed, an environmental assessment plan should be developed that identifies potential effects to fish and wildlife and their habitats from specific components of the mine (as listed above). In addition, the assessment should include cumulative effects of nearby mines (if appropriate) on fish and wildlife habitats and water quality.

Among the most important issues that must be addressed are transportation, potential for acid mine drainage and metals leachate, control of point and non-point pollution, and developing the mine for future closure.

Paul Whitney, Ph.D.

Here are a number of other comments that do not fit neatly under the first 13 questions:

1. Unquantifiable wetland and riparian loss. There are many parameters that are supposedly unquantifiable. An example "unquantifiable" parameter is the area of riparian floodplain (page ES-14). Another example is the "unquantifiable area of riparian floodplain and wetland habitat that would be lost…" (page 8-2, first sentence). There are many methods to characterize or delineate riparian floodplain and wetland. For example, information in Table 5-23 and associated text on page 5-69 characterize wetland loss within 100 and 200 meters of the road. This is a rather crude method but it is at least an estimate. Perhaps it would be accurate to say that the area of riparian floodplain and wetland habitat lost was not characterized. Such a statement would be more internally consistent with statements that the natural system is "incompletely characterized" (page ES-25). Better yet, characterize the wetland and riparian habitat losses using one of the many existing methods. Section 8.2 is a good start. An explicit list of wetland and riparian loss estimates seems important for an EPA review. Once a list of potential wetland and riparian losses is tallied, the next question is whether or not it would be possible to compensate for such an impact. If it is not possible, it might not be possible to achieve no net loss of wetland resources.

2. Combinations and Permutations of analyses. The review of the assessment is somewhat complicated by the relationship of certain analyses to following analyses and so on. Take, for example, the use of the Mount St. Helens eruption as a surrogate for a tailings dam failure. One could assume that such an analogy is inappropriate and recommend that it be deleted from the assessment. If this recommendation was followed for an initial baseline, all subsequent information on distance moved, toxicity, remediation, and duration of impact would no longer apply and would presumably be deleted. Alternatively, EPA might further develop the Mount St. Helens eruption analogy and demonstrate why it is a useful part of the assessment. If this is the case, the related following (i.e., secondary) information presented on distance moved, toxicity, remediation, and duration would be

retained. Then, it is appropriate for a reviewer to comment on the adequacy of the following secondary information. Then, it is a possibility that the secondary or following information is not accurate and the reviewer has to consider that it could be dropped or retained. Soon, a reviewer of the assessment document is wondering how to address an unwieldy and hard to follow combination of initial, secondary, and tertiary events. More likely than not, most reviewers do not consider all the combinations and recommendations. As a result, the reviewers' comments could fall short of adequately addressing the restructuring of the main assessment. In short, EPA should not assume that following the reviewers' comments will result in an assessment that addresses the next iteration of initial, secondary, and tertiary comments.

3. <u>Address all levels of ecology.</u> Ecological resources can be characterized at many levels of organization. Populations are often characterized by birth and death rates. Communities are often characterized by species diversity, succession, and associations of species. Ecosystems are often characterized by structure, function, nutrient cycling, and energy flow. From a wildlife perspective, the assessment does a fine job of discussing marine-derived nutrients but concludes that "…the fish mediated risk to wildlife – cannot be quantified given available data…" The assessment could be improved if information regarding community and ecosystem parameters were quantified (or at least addressed at the level that marine-derived nutrients were addressed). Woolington (2009) comments on the importance of certain seral stages for wildlife. I am confident that an interview with him, reclamation specialists, and others at ADF&G could provide a lot of information on community succession, plant diversity, and wildlife habitat relationships. This information, in addition to the insight provided in Appendix C, would provide a much better understanding of possible mine impacts and opportunities for compensatory mitigation. It is also possible that traditional knowledge of villagers might provide insight to understanding plant community and ecosystem parameters.

4. <u>Ecosystem evaluation.</u> The Ecosystem Integrity Section (2.3.5) seems to miss the mark. It mentions the "nearly pristine conditions," with the caveat that approximately 70% of salmon returning to spawn are commercially harvested. This is then described as a managed and sustainable landscape. Maintaining a sustainable resource is not an accurate characterization of a nearly pristine ecosystem. First of all, sustainability means a lot of different things to different people. For example, forests in the Pacific Northwest are managed in a sustainable way but the ecosystem is hardly pristine. Hilborn (2005) discusses the multiple definitions of sustainability. Instead of deciding which definition he likes the best, he indicates that sustainability is like good art – it's hard to describe but we know it when we see it. Second, Hilborn (2005) states: "The record shows clearly that almost all forms of human activity – agriculture, forestry, urbanization, industrialization, and migration – reduce biodiversity of natural flora and fauna. This is almost certainly the case with fishing as well." Hilborn acknowledges the sustainability of the Bristol Bay fishery but I doubt if he would claim that there is no impact of the fishery on the ecosystem of Bristol Bay.

   Rather than emphasizing the nearly pristine conditions and sustainability of the fishery, I suggest that other measureable characterizations of the aquatic and terrestrial ecosystem be measured and quantified. For example, a description of plant communities and succession would provide the reader with a better understanding of how plant communities are naturally maintained, and subsequently, how possible mining activities might alter the successional processes. Failure to address and understand such relationships led to unexpected consequences for down stream plant communities, wildlife diversity, and village residents in the Peace Athabasca (Cordes 1975) Delta when the Bennett Dam was built hundreds of miles up stream on the Peace River. The drastic changes in the ecosystem function were related to changes in just a few inches of water in the delta at certain times of the year. The Bristol Bay assessment would be improved if the expected changes in the hydrographs and sediment transport were related to the successional processes that maintain early successional plant associations such as the alder-willow association, which is important for moose. The write up for moose (Appendix C, page 33) indicates that these early successional associations are maintained by bank scouring. It would be good to know the role of ice dams and anchor ice on current levels of scouring and how changes due to mining might alter these important sustainable functions. The assessment's emphasis on fish and fish mediated impacts runs the risk of missing possible impacts on the terrestrial environment and down stream sedimentation that would not only influence human culture but also the aquatic environment. The impact on terrestrial resources and wildlife is not inconsequential to aquatic resources, at least in my opinion. Throughout my evaluation, I cite references that discuss the importance of specific associations between fish and wildlife

5. <u>Multi-directional fish and wildlife relationships</u>. The assessment's emphasis on marine-derived nutrients and the reduction of this salmon-derived resource only looks at a one-way fish to wildlife interaction. Wildlife to fish functions, such as beaver dam building, are very important wildlife to fish interactions. Both salmonid fish, as well as forage fish, receive benefits from beaver functions such as tree felling, dam building, and food storage (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). This issue is briefly mentioned in Section 5.2.1.2 (para 1) and discussed on pages 5-19 and 5-22, but needs to be expanded to address the benefits for fish. The dynamic process of dam construction and dam decay is important, not only for moving streams across the flood plain, but also for creating a mosaic of plant associations and wildlife (e.g., moose) habitat in and near the floodplain. In addition, such activities create a mosaic of habitat for forage fish. An accurate characterization of the impact of a potential mine and road necessitates, not only an assessment of the loss of fish on wildlife, but also the loss of wildlife and their functions on fish. The influence of wildlife and terrestrial processes and functions on fish discussed in the Cederholm papers needs to be included in the problem formulation step. The dynamic process of beaver dams causing creeks to move across the floodplain should also be a criteria for determining if and where culverts (i.e., versus bridges or causeways) are installed for a potential road (pages 4-36 and 4-63).

6. <u>Measuring fish wildlife interactions.</u> Understanding and addressing the multi-directional interaction of fish and wildlife are facilitated by an approach developed by the Northwest Habitat Institute, introduced in Johnson and O'Neil (2000) and elaborated on the Northwest Habitat Institute web site (nwhi.org). The Interactive Biodiversity Information System (IBIS) database allows an assessment of fish and wildlife interactions and <u>functional</u> characterizations (i.e., ecosystem functions). The IBIS database is a logical extension of the Jack Ward Thomas Wildlife Habitat Relationships and the GAP analysis for the Pacific Northwest. Such an analysis could build on information in the Alaska GAP database and the Natural Heritage Program database in Alaska.

7. Ecological risk assessment for toxic chemicals. The amount of information in the assessment pertaining to ecological toxics risk is impressively large. The amount of time and team expertise needed to adequately review this information is well beyond the scope of the proposed review. If a team was assembled to review this information, I would ask them to consider:

   a. The applicability of a probabilistic risk assessment to address some of the uncertainty associated with the deterministic information presented in the assessment;
   b. Stressors in addition to toxics (e.g., habitat loss, noise, human disturbance, light, and water warming in the winter); and
   c. The relationship of stressors to populations in addition to no observed effect levels.

   I have worked on large scale impact assessments where the stress of habitat loss far exceeds the potential stress of toxics. I would think EPA would want to know whether or not this is the case for the example mine in their assessment.

8. My only regret in this review is that I could not visit the proposed mine site and watersheds during the summer and the winter. I have flown over the Bristol Bay watersheds while working for other mines in Alaska, but I have never been on the ground in these watersheds. I am concerned that if I did visit the proposed sites my assessment points above might change and even change dramatically. It is hoped that all the EPA staff and biologists working on the assessment are able to visit the watersheds in the summer and winter.

III.3. Specific Observations

David A. Atkins, M.S.

Page	Paragraph or Line #	Comment or Question
Global		All significant figures should be reviewed to make sure they are reflective of the level of uncertainty (i.e., using an estimate of 141.4 km of streams eliminated when this value is probably realistically +/- 50%).
Global		Many references cited in the text are not included in the reference list.
Global		The executive summary, main report, and appendices, in many instances, present different information with sometimes different implications. These three levels of detail of information should be more cohesive.
ES-24	P2	Suggest changing 'Cumulative Risks' to 'Cumulative Effects of Multiple Mine Development.'
3-2	P1	The justification for excluding ancillary development from the assessment should be better explained. In some instances, opening up an area for natural resource development has had as much or more impact on the environment and ecosystems as the development itself (for example, oil and gas development in some areas of the Amazon Basin)
3-7 to 3-11		The conceptual models are quite helpful, but are not referenced or utilized sufficiently when discussing impacts. It would be helpful to more fully incorporate them into the assessment.
4-1	P1, L9	Why does the assessment describe current 'good' and not 'best' practice? The rationale for this decision needs to be described. In addition, it is likely that anything other than 'best' practice would not be permitted in this context.
4-11	P3, L10	The liner lifetime is quite low, and given the importance of this assumption, would warrant more than a personal communication that does not appear in the references (North pers. comm).
4-21	P1, L4	Is the assumption about the TSF locations from the authors or from the Wardrop 43-101 report?
4-26	S4.3.7 – Water Management	It would help to provide appropriate ranges for numbers (e.g., the precipitation at the mine and TDF is 803 and 804 mm/yr, respectively, which implies an unrealistic degree of certainty). It would also be helpful to include a diagram. I am uncertain why 'cooling tower' water losses would be included in the mine water balance since power generation would likely be at a remote location and other impacts from power generation are not considered in this assessment.
4-31	P3, L6	How was the filling time of 100 to 300 years for the pit estimated? What constitutes full (e.g., within x% of the pre-mining water table)?
4-52		The PMP is based on the Miller (1963) reference (not included in the reference list). How was it estimated?

David A. Atkins, M.S.

Page	Paragraph or Line #	Comment or Question
5-22	P4, L4	Should refer to 'recapture efficiency' rather than 'recovery rate'. How were the values of 16% and 63% derived?
5-23		The mean annual unit runoff values are not reproducible from the values given for drainage area and measured mean annual flow.
5-32 to 5-39		Tables showing flow changes for different mine sizes and figures for minimum mine size are difficult to interpret. A different presentation method and/or narrative description would help.
5-45	S5.2.3	The preceding section (Section 5.2.2) focuses on 'Effects of Downstream Flow Changes' and Section 5.2.3 focuses on wastewater treatment. It is not clear why this is the sole focus of Section 5.2.3. In addition, only a short paragraph is included in this section. Certainly there are other possible risks beyond water treatment, and even this discussion is too cursory given the importance of the issue.
5-45	S5.2.4	This section states a number of assumptions that could result in under or over estimating impacts on stream flow from the mine footprint. This section leaves the impression there is a lot of uncertainty, both with assumptions behind the estimation and with how successful any attempts at mitigation may be. Therefore, we are left with very large error bars on estimates that should be reflected in the numbers presented for loss of length of streams and areas of wetlands.
5-46	P3	This paragraph discusses the possibility that estimates of stream length blocked by mine construction may be overestimated if engineered diversion channels are successful. This is an important form of mitigation that needs to be evaluated further. It would be helpful to evaluate mitigation efforts in similar types of systems to determine if reconstructing streams is feasible and could be successful.
5-59	Bullet 4	Whole effluent toxicity (WET) testing and downstream biotic community monitoring would likely be part of any discharge permit. This requirement would not preclude developing a better understanding of protective discharge chemistry and temperature requirements before permitting, especially given the quality of the receiving water.
5-60	S5.4.2	The statement that mine traffic will not be a large enough volume to affect runoff needs support. Do we know the road will only be used for mine traffic? Can we estimate the volume of mine traffic for a mine of this size and then look at runoff from an analog system?
5-60	S5.4.4.1	How was the number of stream crossings determined (e.g., what criteria were used to define a stream vs. a channel)?
5-65 to 5-68	S5.4.8.2	Text states that 240 km of stream upstream of the transportation corridor has a gradient greater than 10% and, therefore, is likely to support fish. Should this be less than 10% (as stated in the header to Table 5-22 and Table 6-9)? If so, how was the <10% value chosen?

David A. Atkins, M.S.

Page	Paragraph or Line #	Comment or Question
5-74	S5.5	Salmon-mediated effects on wildlife seems under-analyzed in the report, particularly when compared to the information presented in Appendix C.
5-75	S5.6	As above, salmon-mediated effects on Alaska Native Cultures seems under-analyzed in the report, particularly when compared to the information presented in Appendix D.
6-3	S6.1.2.1	I don't find the Mt. St. Helens analogy useful.
6-9	P1, L1	Why would 'present' resident and anadromous fish not suffer habitat loss in the event of a TSF failure? Are they upstream of the area inundated?
6-28	S6.1.5	The 'Weighing Lines of Evidence' section is not well developed and not particularly useful. It also does not inform the risk characterization and uncertainty discussion.
6-30	P1, L2	The statement that risks of failure of the gas and diesel pipelines are not considered because they are not particularly associated with mining makes no sense. Without the mine, there would be no need for the pipeline. And if the types of failures and risks are well known, then this is one of the areas that could actually be assessed with some degree of certainty.
6-36	S6.3, P2	Designating closure as 'premature closure,' 'planned closure,' and 'perpetuity' with water treatment ceasing immediately, continuing until permits are exhausted or water is nontoxic, or until institutions fail does not seem reasonable. Any of these closure scenarios would be planned, and would involve regulatory compliance reviews, bonding, etc. Walking away without continuing to collect and treat water would be an unlikely scenario. The issue of treatment in perpetuity is a larger issue that needs to be treated in detail.
6-37	P4, L4	The report states that (acid generating) waste rock could be left in place in the event of premature closure. This scenario should be addressed in the mine closure plan and during the closure bonding process
8-1 to 8-2		Given that this chapter discusses overall risk to salmon, it would be helpful to put the estimates of km lost in terms of the total stream or watershed available habitat. We need some context and metric for assessing significance.
8-2	S8.1.2	The focus on a few types of catastrophic failures does not reflect the current typical mining scenario. Based on experience at other mines, it is more likely that smaller-impact failures and accidents would occur during the mine life. It would be helpful to use some current case studies to illustrate this point.
8-3	T8-1	Why would most concentrate pipeline failures occur between stream and wetland crossings?

Steve Buckley, M.S., CPG

Page	Paragraph or Line #	Comment or Question
xii	1	ICF is referred to in the document page xvi, but not listed as acronym or abbreviation.
ES-2	P2, line 5-6	"altered by geologic processes but would not degrade…" is unclear.
ES-24	P4, line 2	"geologic defects" is unclear.
1-1	P3, line 1	" 17 existing mine claims…" should read "existing claim blocks"
4-11	P3, line 10	"North pers.comm." There is no reference, date or information on North.
5-20	P4, line 3	The "northeastern United States" not comparable to western Alaska.
7-1	P1, line 5	"claims blocks" should read "claim blocks."
7-3	P3, line 4	As above.
7-6	P2, line 5	As above.
7-7	P2 and P4	As above.
8-1,2	P3 and P2	In the discussion of removal of stream kilometers and wetlands it would be helpful to express these numbers in a percentage of the overall watershed stream kilometers and wetlands to put perspective on these numbers.

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
ES-2	3rd paragraph (p)	"wildlife and the Alaska Native cultures *of this region*."
ES-5	2nd p	"Chief among these resources are world-class commercial, sport, *and subsistence* fisheries for Pacific salmon…"
ES-8	Last p	1. Should Alutiiq (Sugpiaq) cultural group also be included? Alutiiq residents noted in Igiugig and Kokhanok (Appendix D, p 15). 2. Change 2nd sentence to: "In contrast, the salmon base upon which indigenous peoples in the Pacific Northwest depend is severely threatened."
ES-9	1st p	"Salmon are integral to the entire way of life in these cultures as subsistence food, *fishing and subsistence-based livelihoods*, and as the foundation for…"
ES-9	2nd p	"52% of the subsistence harvest, *although for some communities this proportion is substantially higher*" (e.g., noted to be as high as 82% on pg 93 of Appendix D).
ES-10	1st p	Could also add replacement value for subsistence resources or for salmon, and the range of estimates for economic valuation of subsistence presented in Appendix E, noting of that economic valuations do not fully capture the value of these practices.
ES-14	#1	Are these all the fish spp at risk, or only the one deemed to be commercially, recreationally valuable? Subsistence spp also include others. Should make clear what the focus is.
ES-23	3rd full p	As noted above, other mines in Alaska (e.g., Red Dog) and oil and gas development studies on North Slope may be useful to include

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
		predictions about how subsistence practices will change with mining development and perceived impacts. Including citations with these statements would be helpful.
ES-23/24	Last p	"if salmon quality or quantity is adversely affected *(or perceived to be affected)*"
ES-26	Last bullet point	There is much data on cultural disruptions caused by the Exxon Valdez oil spill, and cumulative effects of oil and gas development in North Slope region, current salmon shortages in Yukon-Kuskowkim. Clearly subsistence is not about lost food, but about lost lifeways, loss of practices, loss of teaching/learning, and loss of identity. This point could be made more forcefully. While the specific impacts may not be entirely predictable, there are likely outcomes that could be included based on experiences in other regions of the state and/or world.
1-2	2nd p	"this assessment does not provide an economic *or social* cost/benefit analysis…"
2-15	1st p	Other important subsistence fish spp not listed in Table 2-5, e.g., whitefish and winter freshwater fish are listed as integral subsistence species in Appendix D. Again make focus here clear.
2-18	Section 2.2.4	The net economic valuation ranges presented in Table 73, Appendix E would be helpful to include here.
2-19	Last full sentence	"because no alternative food sources are economic viable." This is a bit of a misrepresentation. The point is that people choose to live subsistence lifestyles. Even if food at the stores was cheap, many would choose not to substitute for subsistence hunting, fishing and gathering. This narrow economic framing misses the cultural and lifestyle component of subsistence, and frames it merely as food procurement. This is not the case throughout the document, but in this instance I would suggest changing this sentence to reflect the irreplaceability of the subsistence lifestyle (dependent on access to high-quality foods) rather than the economic viability of substituting alternative food sources.
2-20	First sentence	Here and in Appendix D, the legal framework for federal and state definitions of subsistence should be clarified. Several times in Appendix D an indigenous subsistence priority is noted (e.g., pg 88: "No other state in the United States so broadly grants a subsistence priority to wild foods to indigenous peoples as does Alaska."). The authors should clarify what they mean by indigenous preference (i.e., as opposed to rural preference?) in state and federal subsistence management. They should include particular references and additional clarifying information.
3-2	1st p	"would be benign or have no effect on the environment *or social systems*,"
3-4	1st p	"…provide subsistence for Alaska Natives *and others*." Particularly because subsistence is defined as a rural right in Alaska, all subsistence users should be included as potentially affected groups.

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
3-11	Figure 3-2E	This conceptual model appears less developed than the others. It would interesting to work on expanding it out to include missing dimensions; e.g., add health and healing activity (in addition to nutrition), cultural continuity (alongside social relations and linked to language and traditional ways of teaching). With a decrease in economic opportunities comes an increase in reliance on transfer payments. Overall it is a nice illustration, but strikes me as less complete than the others.
4-15	Table 4-3	1. Estimation of 200,000 metric tons of ore processed per day is much higher rate than any of the other mining operations listed in Table 4-4. Is this due to the low/moderate quality of the ore?
4-21	Last p	208 m high dam is "much higher than most existing tailings dams." What are average dam heights? Or how much higher than most existing tailings dams? Does this high height affect probability of failures?
4-23	2nd p	"a well field spanning the valley floor." This is unclear. Could it be added to Fig 4.7? How often would groundwater be monitored?
5-48	1st full p	"effluents would be required to meet criteria." How different is treated discharged water from unaffected water?
5-59	2nd bullet point	Is there any information available on ore processing chemicals, how much are used, and likely toxicities?
5-76	Bullet list	The list of cultural factors that may be negatively impacted could include others: individual, community, and cultural identity; sense of place and place attachments; community sustainability; cultural unity/conflict avoidance.
6-46	Bullet list	In addition to the two listed, another should be added noted that subsistence practices (harvesting, processing, sharing, consuming) are important for psychological, social, emotional, and cultural health and well-being.
6-47	1st p	"…the physical, *psychological, social, and cultural* benefits of engaging in a subsistence lifestyle…"
6-47	1st p	References should be added (and were included earlier in report) for the statement: "would likely employ a small fraction of Alaska Natives."

Comments specific to Appendices:

Appendix D:

- Single-space for consistency with the rest of appendices.
- The title is a bit misleading. Only eight pages in the report discuss traditional ecological knowledge, and here not in much depth.
- The research design, methods, and data analysis should be described in more detail. Clarify sampling procedure (both for communities and individuals). For example, it is unclear if younger generations, particularly active subsistence harvesters, were targeted as well as elders and culture bearers. Interview protocol should be included clearly as an

Appendix.

- This section may make a few overstatements (e.g, "only in Alaska are wild salmon abundant").
- P12 – "those outside of the state." Change to "outside the *region*," as many urban Alaskans are not familiar with subsistence communities.
- P12 – "Since the questions dealt with a cultural standard, there were few alternative points of views." Should cultural agreement be a matter of investigation rather than assumed? This statement needs to be justified. Perhaps with the authors' 40+ years of experience working with these communities they have come to expect cultural agreement, especially among elders. If this is the case, that should be clarified. To what extent did group interviews (2-6 people interviewed together, except for one single interview) also contribute to cultural agreement? These details are important given that the results are given on an agree/disagree format.
- P17 – 2,378 is listed in Table 2 and 2,329 is listed here.
- P19 – Here is perhaps another example of overstatement – 100% of the population has access to waters of the rivers and lakes. What is meant here? For subsistence, this access depends upon having transportation and gear or social relations. Do 100% of people have this in this region?
- P20 – Reword "the archaeological work is largely due to five projects."
- P26 – "located along a salmon stream indicates salmon were *likely* a primary resource."
- P31-32 – Several of these quotes focus on social changes (e.g., elimination of dog teams, relationships to commercial fishing changing over time). People likely harvest less fish now because they do not support dog teams, yet now they need more money for fuel and equipment. These are important considerations for understanding contemporary mixed economy. These points are mentioned in this cultural characterization, but perhaps could be made a bit more clearly. At times, even the contemporary characterization reads a bit like "timeless" traditional cultural relationships to the land and resources, yet it is important to accurately characterize the subsistence-based communities in their full contemporary realities and complexities.
- P34 – "Large disruptions to the population *have not been documented to* occur until epidemic…"
- P34/35 – Both kashgee and qasgiq are used for men's house – it is also defined three times over these first few pages of this section.
- P35 – "earlier bow and arrow wars" should either be explained or omitted.
- P38, first full paragraph, last sentence – What is meant by "observe the practice?" This general statement is not adequately supported. Authors should provide specific instances or more discussion if this point is to be included. As written, it risks conveying a static view of TEK and practice and culture. Many indigenous communities in Alaska, e.g., Kodiak villages, while exploited by a colonial economic system, also strategically adapted to benefit from those systems in ways compatible with their village lifestyles (e.g., cannery and village co-dependencies that elder fishermen in this region remember fondly; Carothers 2010). It would be helpful to have more information on this context in this region (e.g., Hébert 2008; Donkersloot 2005).
- P40 – More information would be useful on Alaska Native participation in commercial fishing in this historic period up through the present.
- P47-48 – Ellam yua and tnughit are defined twice.
- P81-84, Table 9 – Second/third part of questions not explained. Since this is an agree/disagree table, remove other questions for which no information is presented. All

questions would ideally be contained in an interview protocol attached as an appendix.

- P87 – 'non-monetized' – but important to note that the modern subsistence economy now depends upon cash inputs (ATVs, boats, snow machines, gas, parts, repairs, guns, nets, etc.).
- P88 – First full sentence, last sentence is poorly worded.
- P89-90 – The subsistence discussion is confusing.
- P92-93, Tables – Update with recent data if possible.
- P100 – If percentage of working age population not in labor force is a better measure, it should be included rather than official unemployment rates (or in addition to).
- P110 – "Villagers in the study also eat store-bought foods, but do not prefer them" – make clear again that most residents interviewed were elders or identified culture bearers. A concern for many subsistence villages in other regions of Alaska is the displacement of younger generations from fish camp and other subsistence practices, and preferences for store foods, particularly candy and soda. If this region is unique in that regard, make that clear here.
- Section C "Physical and Mental Well-being" – Subsistence for emotional/mental health should be added as a sub-section here. Given the high rates of social problems in Alaska Native villages (e.g., suicide, violence, addiction), many cultures talk about subsistence practices as being healing activities or producing emotion, spiritual and/or mental health. This important aspect isn't covered in the other sub-sections.
- P113 – Makhoul et al. is listed as 2010 in references.
- P114 – Change Local Wild Fish *and Local Practices*, and "ecologically, *socially, culturally, spiritually,* and possibly even evolutionarily." Point is that subsistence salmon are not just vehicles for protein and nutrition, but form the basis of incredibly important subsistence ways of life that are irreplaceable.
- P115 – Add 'cultural and social disruption' to the list of risks.
- P152, 2nd and last bullet points – These are risks of mining development, not of decreased quality/quantity of fish (defined as outside the scope of this assessment). The last bullet point would apply to fish-effects if reworded – some community members may decide it is not safe to eat fish, causing factions of those who express concern and those who do not. Others to possibly include: cultural loss as younger generations do not learn the practices of subsistence; stress on other areas and communities of the region where people may target subsistence resources; and health risks of eating contaminated fish.
- P156 – Sing to sign.
- Several grammatical errors throughout.

Appendix E:

- P9 – Components of total value should include indigenous homeland for Alaska Native cultural groups.
- P12 – Clarify usage of Aleut (Alutiiq/Sugpiaq?).
- P22 and 26 – Change Boraas citations to Boraas and Knott.
- P32 – Much of recreational use is non-market and could be included in the list at end of 2nd paragraph.
- P96 – Citation for typical crew share of 10%?
- P122 – Reasons for differences in earnings between local residents and others is important. The mixed subsistence-cash economy and cultural ideas about commercial work in this region may offer an explanation. See: Koslow 1986, Langdon 1986, Carothers 2010.

- P134 – Ugashik, Egegik, and South Naknek have over 30.
- P136, last paragraph – This paragraph seems abrupt/misplaced. A more thorough discussion is needed here to include these points.
- P178, Section 4.3 – No discussion of role of regional and village Native corporations or the Community Development Quota program for federally-managed fisheries.
- P191 – While the majority of formal sector jobs are taken by nonresidents, may want to note that local economy – subsistence – is all local and highly dependent on resources of the region.
- P193 – 2009 is mentioned as an unrepresentative year and given a sensitivity ranking of "high." More information should be included on the anomalous 2009 – in what direction should we expect to interpret data from this year compared to more average years, or those at other ends of the extremes?
- P195 – Number of households engaged in subsistence – ADF&G data should provide estimates.
- P198 – ATV, snow machines, should be added to "boats and trucks"; work by Robert Wolfe and others (Wolfe et al. 2009) suggests that about one third of households in Alaska Native villages harvest the majority of subsistence foods (and share, especially with the least active households). How does this finding affect these estimates?
- P202 – Explain why % of adults with 4+ years of college is used in this model? The model was not explained clearly enough for me to understand it.
- Some fisheries, e.g., crab fisheries, are not included in the economic analysis, yet depend in part of Bristol Bay ecosystem, as discussed in Appendix F.
- References – Peterson et al. 1992 and Brown and Burch 1992 not included in references.

Appendix G:

- Mitigation measures are largely concluded to be ineffective. Would be helpful to compare mitigation measures and their success/failure in other mining examples.

Appendix H:

- P7 – Exposure of groundwater and waterfowl to chemical contaminants are listed as main environmental concerns from tailings storage facilities. Impacts to human health from ingesting contaminated water or birds. Clarify in report that direct risks to human health are not accessed (only through reduction or elimination of subsistence harvests?).

References Cited:

Ballard, C. and G. Barks. 2003. Resource Wars: The Anthropology of Mining. Annual Review of Anthropology 32: 287:313.

Braund, Stephen R. & Associates. 2009. Impacts of Oil and Gas Development to Barrow, Nuiqsut, Wainwright, and Atqasuk Harvesters. Report prepared for North Slope Borough, Department of Wildlife Management.

Braund, S.R. and J. Kruse (ed.). 2009. Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska. MMS OCS Study 2009-006.

Carothers, C. 2010. Tragedy of Commodification: Transitions in Alutiiq Fishing Communities in the Gulf of Alaska. MAST 90(2): 91-115.

Colombi, B. J. and J. F. Brooks. 2012. Keystone Nations: Indigenous Peoples and Salmon Across the North Pacific. Santa Fe: School for Advanced Research.

Donkersloot, R. 2005. Ecological Crisis, Social Change and the Life-Paths of Young Alaskans: An Analysis of the Impacts of Shifting Patterns in Human-Environment Interaction in the Fisheries-Dependent Region of Bristol Bay, Alaska. Masters Thesis. Missoula: University of Montana.

Fall, J. A., N. Braem, C. Brown, S. Evans, D. Holen, T. Krieg, R. La Vine, T. Lemons, M. Marchioni, D. Runfola, L. Hutchinson-Scarbrough, L. Sill, A. Trainor, and J. Van Lanen. 2012. Alaska subsistence salmon fisheries 2009 annual report. Technical Paper No. 373. Anchorage: Alaska Department of Fish and Game, Division of Subsistence.

Hébert, K. 2008. Wild Dreams: Refashioning Production in Bristol Bay, Alaska. PhD dissertation. Ann Arbor: University of Michigan.

Holen, D. 2009a. The Dynamic Context of Cultural and Social Sustainability of Communities in Southwest Alaska. Journal of Enterprising Communities 3(3): 306-316.

Holen, D. 2009b. A Resilient Subsistence Salmon Fishery in Southwest Alaska. Journal of Northern Studies 2: 99-113.

Holen, D. 2011. "We all Drink this Water:" The Contemporary Context of Salmon Fishing in Southwest Alaska. Pages 191-208 in Humanizing Security in the Arctic. D. Michelle, F. Levesque and J. Ferguson (eds). Edmonton: Canadian Circumpolar Institute.

Kenner, P.C. 2005. From Neqa to Tepa, Łuq'a to Chuqilin: A Database with Traditional Knowledge about the Fish of Bristol Bay and the Northern Alaska Peninsula. Alaska Department of Fish and Game, Division of Subsistence. Final Report for US Fish and Wildlife Service, Office of Subsistence Management, Project No. FIS 02-034. Anchorage.

Koslow, A. 1986. Limited Entry Policy and Impacts on Bristol Bay Fishermen. Pages 47-62 in S. Langdon (Ed.) Contemporary Alaskan Native Economies. Lanham, MD: University Press of America.

Langdon, S. J. (Ed.) 1986. Contemporary Alaskan Native Economies. Lanham, MD: University Press of America.

Langdon, S. J., S. Colt, M. King, and S. Sharp. 2006. BBNA Pebble Mine: Technical Assistance Project. Final Report prepared for Bristol Bay Native Association. Anchorage: Institute for Social and Economic Research, University of Alaska Fairbanks.

National Research Council (NRC). 2003. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. Washington D.C.: The National Academies Press.

Palinkas, L.A., M.A. Downs, J. S. Petterson, and J. Russell. 1993. Social, Cultural, and Psychological Impacts of the *Exxon Valdez* Oil Spill. *Human Organization* 52(1):1-12.

Storey, K. and L.C. Hamilton. 2004. Planning for the Impacts of Megaprojects: Two North American Examples. Pp. 281-302 in R.O. Rasmussen and N.E. Koroleva (eds.) *Social and Economic Impacts in the North*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Tetra Tech. 2009. Red Dog Mine Extension Aqqaluk Project Final Environmental Impact Statement October 2009. U.S. Environmental Protection Agency Region 10.

Wolfe, R., C. Scott, W. Simeone, C. Utermohle, and M. Pete. 2009. The "Super-Household" in Alaska Native Subsistence Economies. Final report submitted to National Science Foundation (ARC 0352611).

Dennis D. Dauble, Ph.D.

Page	Paragraph or Line #	Comment or Question
App. B, page 30		Table 1. I suggest adding a column to indicate relative abundance, for example, if individual fish species listed are abundant, common or rare. Also, are there known differences in distribution and abundance for the Nushagak and Kvichak watersheds relative to those watersheds unlikely to be affected by mining activities?
App. A, page 42	1st para.	The statement that diminished salmon runs present a "negative feedback loop" where spawner abundance declines, appears to conflict with the last paragraph on page 41.
App. F, page 3		Is there significant sediment transport from the Bristol Bay watershed to the Nushegak and Togiak Bays/estuaries?
App. F, page 7		What is the juvenile salmon resident time in Bristol Bay? How quickly (and at what size/time of year) do they move from shall nearshore to offshore habitats?
Page 8-15	Line 2	Suggest deleting "likely." There will be impacts.

Gordon H. Reeves, Ph.D.

Page	Paragraph or Line #	Comment or Question
6-9	Para. 1	Why would resident fish not "suffer" immediate loss of habitat as a result of dam failure like anadromous fish would?
6-42	Para. 5	Couldn't fish move to another stream to spawn if a culvert is blocked and prevents upstream movement? This may eliminate the fish from a particular stream for a year but it might not reduce the overall productivity.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
Entire Assessment		Provision of full color versions of all figures would have been helpful to this review. The selected color versions supplied were useful – we should have had them all.
2-4		Color codes are confusing – use of different colors for same "moisture state" in the five regions doesn't make sense (to me).
3-4	Section 3.4, line1	….when mine ***is*** active
4-5	Last para.	Refers to Fig. 3-1, but "existing road segments" listed are not shown on Fig. 3-1, nor are several cited locales: Williams Port, Pile Bay, King Salmon, and Naknek.
4-11	First para.	"The vast majority of tailings dams are less than 30 m in height…" DOES THIS REFER TO TAILINGS DAMS AT ALL KNOWN MINING OPERATIONS, OR TAILINGS DAMS ENVISIONED OR PROBABLY TO BE USED IN BRISTOL BAY WATERSHED?
4-11	First para.	"Although upstream construction is considered unsuitable for impoundments intended to be very high or to contain large volumes of water or solids….this method is still routinely employed." ARE THE TSFs SUGGESTED IN THIS ASSESSMENT CONSIDERED "UPSTREAM," "DOWNSTREAM," OR "CENTERLINE"? Para. 1, Section 4.3.5 (p. 4-21), states that "the most plausible sites" for TSFs are "the higher mountain," which suggests that these TSFs would be "upstream" facilities, therefore "considered unsuitable…"
4-23	2nd para.	Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.
4-26 – 4-28	Section 4.3.7	This "Water Management" section seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; and "Precipitation…would be collected and stored…." do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen) would be planned for or actually managed adequately.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
4-29	First para.	Suggests that 20% more water than available would be required "during startup," and that difference would be satisfied "from water stored in the TSF"; if 20% more than is available would be needed, where would it come from to be available from the TSF?
4-29	3rd para.	Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures" and "excess captured water would be treated…and discharged to nearby streams..." – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendices A & B).
	Section 4.3.8 – Post-closure Site Managemen t	This and the previous section mention (but in my view, do not adequately stress) the extremely long time frame for post-mining active management and oversight. Many hundreds of years of active management is a longer time than many industrial, corporate or governmental entities are capable of really embracing – witness the current US Congressional practice of "kicking the can down the road" – a human trait.
4-32	Section 4.3.8.2, 3rd para.	Suggests that pyritic tailings could be "shipped off site" – i.e., to where? Deep ocean dumping, or Yucca Mountain?
4-34 - 4-37	Section 4.3.9 – Transportati on Corridor	This reviewer finds the short Transportation Corridor sub-chapter to be succinct, but inadequate and superficial in view of the long-term consequences of imposition of the transportation corridor as portrayed. These deficiencies are addressed, in part, in other sectors of the Assessment, most comprehensively in Appendix G.
4-38	Box 4.3, para. 2	Para. 2 states that the southwest extension of the Lake Clark Fault is currently understood to extend to perhaps 16 +/- km from the Pebble ore deposit; however, this is not reflected in Figure 4-11, which suggests that the Lake Clark Fault terminates perhaps 100 km northeast of the Pebble locale. Elsewhere in Box 4.3, there is acknowledgement that, while there is no evidence of recent tectonic activity in the immediate Pebble vicinity, there is relatively little site-specific data or long-term historical seismic record. I infer that any predictions concerning seismicity or earthquake occurrence of any magnitude would have very high uncertainty.
4-41	Box 4-4	Note that in each of the four tailing dam failure examples, the failed structure was roughly an order of magnitude **smaller** (in height) than the hypothetical TSF-1 structure, yet those failures had major negative consequences.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
4-45 - 4-47	Section 4.4.2.2	The probability approach to tailing dam failure is unpersuasive as presented. It is difficult to relate to a number like "0.00050 failures per dam year," or to the implication (p. 4-47) that one can expect a tailings dam failure only once in 10,000 to one million "dam years." This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.
4-48	Box 4-6	Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult interpret, given the lack of historical seismic record for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."
4-50 - 4-60	Section 4.4.2.4	The modeled hydrologic consequences of overtopping/flooding of the hypothetical TSF1 dam/reservoir seem reasonable, given the relatively limited hydrologic data set available for model input. Probable Maximum Precipitation and Probable Maximum Flood results should be approximately "correct" and within the same order of magnitude of potential storm and flood events. The potential consequences outlined (peak flow volume, sediment transport and deposition, length of stream corridor impacted) appear realistic for the scenario. I suggest that this topic and hypothetical result should be given more visibility and emphasis in the assessment.
4-62 - 4-63	Section 4.4.4	While accurate, this section does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings are a major concern for aquatic habitat and fisheries. This issue receives more attention in Sections 5.4 and 6.4, and is mentioned elsewhere in Volume 1 (e.g., Table 8.1, Box 8-1, para. 8.1.2.4.). Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.
	Chapter 5	Assumes scenario of "no failure" for entire project, over complete project life. Is this a realistic scenario, given experience with industrial developments in real-world settings subject to vagaries of equipment, landscape, geology, weather, local climate, and human judgment and decision making/execution?

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-1	Section 5.1.1	Question: is "sampling extensively for summer fish distribution over several years" adequate for characterizing fish populations, given the wide fluctuations in salmon escapement and return note elsewhere in the Assessment (e.g., Table 5-1, para. 5.1.2)?
5-12 - 5-48	Section 5.2	Estimates of habitat, wetland and stream blockage or loss seem reasonable, but, as noted in the text, are probably conservative or "at the low end." Estimates of probable streamflow diminution (p. 5-25) seem reasonable, but make no reference to seasonality.
5-29 - 5-30	Thermal Regimes	This section makes no mention of aufeis or "nalyds," ice accumulations which can exert major control on spring and early summer habitat availability and thermal conditions. For examples, see Slaughter (1990), among many other references.
5-30 - 5-31		Concur that maintenance of natural flow regime is the desirable target; the "sustainability boundary" approach is a way to attempt managing within the "natural" bounds of variability. Note: Figure 5-9 is map of streams and wetlands lost, <u>not</u> predicted flow alteration hydrograph (see last sentence, p. 5-31).
5-37	Figure 5-10 Upper Talarik Creek	UT100D – predicted flow is ALWAYS below lower 20% sustainability boundary. UT100C, UT100C1, UTC100B – predicted flows are always within the 20% +/- sustainability boundaries.
5-38	Figure 5-11 South Fork Koktuli River	Predicted flow for two upper gages (SK100G, SK100F) is always below the 20% sustainability boundary. Predicted flow at other gages appears to be near or within the 10% and 20% lower sustainability boundary.
5-39	Figure 5-12 North Fork Koktuli River	Predicted high flow for NK119A is far below the lower 20% sustainability boundary throughout the open water season. From onset of snowmelt, flow at other gages is roughly at or within the lower 20% sustainability boundary.
5-41		Gage NK119A – is the estimated decrease of streamflow (minimum mine size) 63% (Table 5-13) or 73% (text)?
5-41		In any case, text is clear: predicted flow reductions for North and South Forks Koktuli River are materially below the lower 20% sustainability boundary. Text suggests that while upper Talarik Creek would be essentially obliterated in this hypothetical scenario, lower gaging stations on Talarik Creek might have partial augmentation of reduced flows, from small tributary flows and groundwater; without supporting data, this suggestion seems unsupportable.
5-42 - 5-45		These pages fairly summarize the potential for substantive alterations to streamflow regime and surface water/groundwater relationships.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-44	3rd para.	"Once the mine is no longer a net consumer of water, we assume that flow regulation through the water treatment facility could be designed to somewhat approximate natural hydrologic regimes, which could provide appropriate timing and duration of connectivity with off-channel habitats." I suggest that this is a highly optimistic assumption, and does not address water quality questions (which are raised elsewhere in the Assessment).
5-45	Section 5.2.3	This entire paragraph should receive greater emphasis.
5-46	4th para.	Ignores variable-source-area concepts, which are widely accepted in hydrologic and watershed analysis.
5-46	5th para.	Assumes requirement for more water than is available, but leaves hanging the question of where that more water might be sourced. Given that the site is a watershed headwaters, what might be tapped as additional water supply, and what might be the impacts on that source(s)?
5-59 - 5-63	Section 5.4 – Roads and Stream Crossings	See earlier cautions concerning stream crossings, culverts. Note that road cuts and culverts are particularly susceptible to development of aufeis ("icings"), often resulting from blockage or alteration of subsurface water movement during cold conditions, as witnessed by long-standing AKODT maintenance issues – Richardson, Steese, Dalton highways, for example.
5-60	Section 5.4.2, first para.	The statement that "…it is unlikely that a mine access road would have sufficient traffic to significantly contaminate runoff with metals or oil" is unsupported; it might be instructive to look at traffic loads for the access road from the Steese Highway to the Ft. Knox mine, a much smaller operation than the proposed Pebble development.
5-60	Section 5.4.2, 2nd para.	First sentence is correct. Second sentence is unsupported and probably incorrect (see Appendix G). Yes, runoff from roads is location-specific; that **does not** mean that runoff from roads would be insignificant to salmonids, given the very large number of streams (perennial, intermittent, and ephemeral), and wetlands, which would be intersected by the total road system of the Pebble project. This also seems to be contradicted by Section 5.4.3.
5-60	Section 5.4.4.1	There are many more water or seep crossings than 34 – see USGS topog sheets, ACME Mapper, or Google Earth.
5-61	Sections 5.4.4.2 and 5.4.4.3	Development of aufeis ("icings") consequent to partial or full culvert blockage, or induced by soil mantle compaction (i.e., by roads or off-road vehicle traffic) can partially or wholly block stream channels. Such blockage, in association with ice on the streambed, may last long past snowmelt and persist well into early summer, possibly affecting fish movement.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-62	Section 5.4.5	While I don't have the specific citations at hand, there are published analyses of dust effects associated with the North Slope haul road and Prudhoe Bay road network. Obvious effects include accelerated snowmelt along the road corridor, and nutrient or pollutant contributions to road corridor environs.
5-63	Section 5.4.6.3	Should it read "…*impacting* 270.3 km of stream…"? (Incidentally, it is interesting that this coarse assessment finds it possible to state impact to within 100-meter resolution.)
5-65	Sections 5.4.7.3 (and 5.4.8.3)	Viewing the transportation corridor landscape, via maps, Google Earth or ACME Mapper, gives me the impression that the estimate of 4.9 km^2 wetlands directly impacted is a very low number. It is easy to play with the numbers given on pp. 5-69 - 5-70, regardless of their accuracy; 66 km of road impacting wetlands, assuming a 10-meter roadway footprint, yields 0.66 km^2 of wetlands "under the road" (vs. 0.18 km^2 in the text). The 200-meter proximity to wetlands cited, over 66 km of road, yields some 13 km^2 of wetland impact (vs. 7.3 km^2 in the text). 80 km of road within 200 m of streams or wetlands yields 16 km^2 of road/wetland impact. Since these are all assumptions and estimates, it is not possible to conclude that any of these figures would be the "true" area impacted.
5-74	Section 5.4.10	Should this say ***impact*** rather than "risk"? Text implies that even this "no-failure" scenario will impact salmonids; however, it is apparently not possible to estimate specific changes or the magnitude of such changes.
5-74 – 5-77	Section 5.6	This section seems cursory and understated, particularly in view of the extensive discussion of Appendix D.
	Section 6.1	Concur with general overview statements, and with conclusions regarding immediate consequences of TSF dam failure, which would likely be as severe as or more severe than stated in 6.1.2.1. P. 6-6, first sentence – note that the failure scenario predicts over 70% fines < 0,1 mm, vs. the 6% "natural" fines concentrations. P. 6-13, last para. – the assumption that overtopping would not occur in winter is not warranted, as the authors admit when citing the Nixon Fork Mine incident. In the Bristol Bay environment, a major rain-on-snow event in winter or spring is within the realm of possibility, and of course human error is, if not inevitable, always possible.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
6-15	Box 6.2	Box text implies that human error, lack of timely oversight and correction was responsible – but never directly says "human error." The apparent assumption that there is no hydrologic activity after freeze-up (or perhaps, after an ice cover forms on the pool) was naïve and incorrect. At least in that case, it appears that both dam and spillway design (not adequately considering winter and ice conditions) and operation/inspection (human error) were responsible.
	Section 6.1.4.1	Appropriately recognizes the long time period for exposure, over extended stream lengths, through both initial deposition and multiple re-mobilization and redeposition events.
6-28	Section 6.1.5 and Table 6-6	Seems jargon-laden and does not add to strength of the Assessment.
6-29	Section 6.1.7	Concur that remediation "…would be particularly difficult and damaging…."
6-30	Section 6.2	Even though "We do not assess failures of the natural gas or diesel pipelines…," those pipelines would be equally susceptible to failure as the slurry line. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. Similarly, I suspect that careful inspection would reveal many more "watercourses," including intermittent and ephemeral streams, than the 70 crossings cited. The "probability" argument on p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there "should be" only 1.5 stream-contaminating spills in78 years of operation seems wildly optimistic. Assuming that any spill (over the 78-year project span) would last only two minutes (pp. 6-32, 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
	Section 6.4	Potential road/culvert failures are recognized (again, not that ice issues are not discussed). Extended periods for repair/rebuilding might be anticipated – witness the repeated problems with the highway to Eagle, AK over the past several years – and that is a State of Alaska responsibility, not that of a private company. Potential for multiple simultaneous or concurrent failures is appropriate. Non-Alaska examples would be the Pacific Northwest flood events of 1964 and 1996, both major precipitation events with widespread flooding and road failures, in a region with much more developed infrastructure and response capacity.
	Chapter 7 – Cumulative Effects	Recognition of probable additional mining activity, in the wake of a Pebble project, is appropriate. Assessment is necessarily limited to currently-known potential mining projects. The cumulative and irreversible consequences of multiple developments, with associated road, power, housing, communications infrastructure ("secondary development") should be more heavily emphasized, even though it is not possible to quantify all those consequences.
	Chapter 8 – Integrated Risk Characterization	Section 8.1.2 – note many potential failure modes not analyzed; the lack of analysis in this Assessment should not be taken to mean that such failure could not or will not occur.
	Table 8.1, Row 2	The reasoning behind the statement that "Most [product concentrate pipeline] failures would occur between stream or wetland crossing [sic] and might have little effect on fish" is hard to understand; stream crossings, whether via elevated utilidors or via sub-channel borings or utilidors, are locales of angular change, piping connections and joints, and subject to stresses of hydrologic extreme events – so why would such sites be less subject to potential pipeline failure?
8-4	Box 8-1	As noted elsewhere, the probability arguments for TSF dam failure are not persuasive, and seem designed to imply that a TSF dam failure would not occur within the next 10,000 years (or 3,000 to 300,000 years with three TSFs operational). This implication is difficult to square with information on actual past failures presented in Box 4-4 and Table 4-8
	Chapter 8	The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with some attention on salmon-mediated impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

Additional references, which may be useful:

Boyle, T.P. (ed). 1987. New approaches to monitoring aquatic ecosystems. ASTM Special Technical Publication 940. American Society for Testing and Materials, Philadelphia PA. 208 p.

Committee on Watershed Management, Water Science and Technology Board, National Research Council. 1999. New strategies for America's watersheds. National Academy Press, Washington DC. 311 p.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Company, San Francisco CA. 818 p.

Kane, D.L., and C.W. Slaughter. 1972. Seasonal regime and hydrological significance of stream icings in central Alaska. pp. 528-554, The Role of Snow and Ice in Hydrology, Proceedings of the Banff Symposium. UNESCO-WMO-IAHS.

Kane, D.L. (ed). 2000. Water resources in extreme environments. Proceedings, AWRA Spring Specialty Conference, Anchorage AK. American Water Resources Association, Middleburg VA. 342 p.

Laenen, A., and D.A. Dunnette. 1997. River quality dynamics and restoration. Lewis Publishers/CRC Press, New York. 463 p.

Naiman, R.J., and H. Decamps (eds). 1990. The ecology and management of aquatic-terrestrial ecotones. Man and the Biosphere Series, Volume 4. UNESCO, Paris, and The Parthenon Publishing Group, Carnforth, Lancs, UK. 316 p.

Reid, L.M. 1993. Research and cumulative watershed effects. General Technical Report PSW-GTR-141, Pacific Southwest Research Station, USDA Forest Service, Albany CA. 118 p.

Ryan, W.L., and R.D. Crissman. 1990. Cold regions hydrology and hydraulics. Technical Council on Cold Regions Engineering Monograph, American Society of Civil Engineers, New York NY. 827 p.

Specific papers in Ryan and Crissman, 1990:

Ashton, W.S., and L.A. Griffiths. Culverts. pp. 557-577.

Kane,D.L.,and E.F. Chacho. Frozen ground effects on infiltration and runoff. pp. 259-300.

Ryan, W.L. Surface water supplies. pp. 301-316.

Nelson, G.L.,and J.A. Munter. Ground water. pp. 317-348.

Slaughter C.W. Aufeis formation and prevention. pp. 433-458.

Rundquist, L.A., and J.E. Baldridge. Fish habitat considerations. pp. 579-613.

Selkregg, L.L. (ed) 1976. Alaska Regional Profiles – Southwest Region. Arctic Environmental Information and Data Center, University of Alaska, for Joint Federal-State Land Use Planning Commission for Alaska. 313 p (large format).

Slaughter C.W. , C.W. Racine, D.W. Walker, L.A. Johnson, and G. Abele. 1988. Use of off-road vehicles and the consequences or Alaska permafrost environments: a review. Environmental Management 14(1):63-72.

Slaughter, C.W., and J.W. Aldrich. 1989. Annotated bibliography on soil erosion and erosion control in subarctic and high-latitude regions of North America. PNW-GTR-253, Pacific Northwest Research Statin, USDA Forest Service, Portland OR. 234 p.

Slaughter, C.W. (ed). 2003. Watersheds Across Boundaries: Science, Sustainability, Security. Conference Abstracts Watershed Management Council Networker, Spring 2003. 35 p.

Smith, E. (ed). 1990. Sustainable development through northern conservation strategies. The Banff Centre School of Management. The University of Calgary Press, Calgary, Alberta. 188 p.

Proceedings, International Conferences on Permafrost: 1968, 1973, 1978, 1983, 1988, 1993, 1998, 2003, 2008

John D. Stednick, Ph.D.

Page	Paragraph or Line #	Comment or Question
ES-9		Economics of Ecological Resources – section seems weak.
ES-14		Overall risk to salmon and other fish. Never really separates fish species out in other discussions. Dolly varden more sensitive to metals?
2-3	Para. 3	Four climate classes. Why this classification system? Perhaps easier to identify by watershed maps?
2-5		Precipitation values – significant figures?
2-23		Monthly values of streamflow. Would be nice to see average or daily streamflows somewhere.
3-7 -11		Would like to see more discussion of conceptual models. If a picture is worth a 1000 words……
4-1	Para. 1	*…represent current good, but not necessarily best, mining practices*. Why not use the best methods or state of the art methods?
4-18		Shaded relief. Perhaps contour lines in another figure?
4-21	Para. 1	*...most plausible sites given geotechnical, hydrologic, and environmental considerations.* Can this be elaborated?
4-21	Para. 2	*The TSF would be unlined other than on the upstream dam face and there would be no impermeable barrier constructed between tailings and underlying groundwater.* Is this correct? I thought I read the whole TSF would be underlain by liner?
4-24		*Leachate Recovered*. This refers to only the leachate collected from the dam face?
4-26		Water management. This is confusing. Collect precipitation for processing, yet divert upstream waters around the mine and not

John D. Stednick, Ph.D.

Page	Paragraph or Line #	Comment or Question
		use? Where are the leachate recovery wells, and are they just a safeguard?
4-28		Significant figures on precipitation estimates? What is the ET and how is it calculated?
4-31	Para. 3	*...the mine pit would take approximately 100 to 300 years to fill.* From groundwater inflow only? Why such a large range of the estimate?
4-50	Para. 3	This peak flow calculation and discussion is confusing and needs clarification.
4-52		What is the recurrence interval of the 356 mm?
4-60	Para. 4	Why a geometric mean using three values?
5-10		Define *highest reported index spawner.*
5-20	Para. 1	*…salmon abundance related to pool size….and beaver ponds provide particularly large pools*. Are data available to characterize the stream type? Are beaver present?
5-22	Para. 2	*Assuming that no natural flow or uncontrolled runoff would be generated from the mine footprint.* Is all precipitation is intercepted or does this refer to the subsurface streamflow generation mechanisms?
5-23		It appears that the mean annual unit runoff is calculated incorrectly.
5-24		Table shows flow returned from footprint. Does not fit with page 5-22?
5-29	Para. 2	Groundwater-surface water connectivity. Are data available to show this connection throughout the watersheds or does the groundwater only return to the hyporheic in the low gradient areas? Similarly, where are the temperature data that suggest the lake and groundwater connection or this reference by incorporation?
5-32-39		The tables and hydrographs illustrating the potential flow changes are difficult to appreciate or interpret. Another means of presentation?
5-41	Table 5-13	The value of 0.15 km affected by the maximum mine size is questioned.
5-52	Table 5-17	Can we see summary statistics on water quality, not just means? Plot of concentrations with streamflow?
5-55		*These effluent specific values are higher than those for background surface water because of the higher content of mineral ions.* This sentence needs clarification.
6-6	Table 6-1	Last line. What is the +/- value after the mean?
6-13	Para. 3	*…an intense local storm.* Why use the Type 1a distribution for precipitation distribution?

Roy A. Stein, Ph.D.

Page	Paragraph or Line #	Comment or Question
Document	See Table 5.3 as an example	Some thought should be given to significant figures for the numerical values given in the report, especially so for Chapter 5, where much uncertainty exists regarding stream lengths blocked (for example) by the mine footprint: "…34.9 km of first- through third-order streams…" will be eliminated. Rounding in this context makes sense for we really do not know this impact to the nearest 0.1 km. I would encourage a thorough review of these values throughout the report.
2-17		Salmon populations are closely managed by Alaska Department of Fish and Game; how closely and what do we know of the populations that are managed regarding numbers, resilience, variability, etc.? A box summarizing the fishery management practiced by Alaska Department of Fish and Game would help put biological resources in perspective.
2-17		The importance of salmonids to marine predators is likely not an issue, given the very large numbers of salmon stocked in the Pacific.
2-20		Nushagak and Kvichak rivers contain >58,000 km of streams; 13% is anadromous fish habitat, but this is likely underestimated. How do we know this is an underestimate? What proportion of this >58,000 km has been surveyed?
2-24	5th text line	"the" is missing between "…of" and "nutrient budgets…"
2-25	Bottom of page	I wonder if a bit more couldn't be written about the idea of a salmon sanctuary, fleshing out the ideas of Rahr and Pinsky here.
3-2		With all the items in the first full paragraph eliminated from consideration (e.g., power generations, worker housing, Cook Inlet Port), might the analysis herein be considered minimal impact on the Bristol Bay watershed?
3-7 to 3-11		These conceptual models might best be placed in the chapter to which they refer; in so doing, it is easier for the reader to follow along. In turn, these models did not seem to be discussed in text to the extent that they drove the impacts generated. Add more explanatory text.
4-5	Bottom of page	Typically, when citing a figure in another chapter, i.e., one not near the current text, the format should be "see Figure 3-1" to keep the reader on track.
4-8		Is there some chance of "block caving" here? Some text clarifying this point here would be appropriate.
Chapt. 4		Could these data and insights be productively moved to Chapter 5, thus reducing redundancy? The organization would be 1) a description of the mine features relevant to the text, then 2) a discussion of salmon and the mining impacts on their habitat. Separating these into chapters seems artificial.
5-20	3rd full par.	What does the phrase, "free-water area" mean? Ice free, perhaps?

Roy A. Stein, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-20 to 5-21		Paragraphs on these two pages reflect some of the redundancy that I saw throughout the report. In the 3rd full paragraph on page 5-20, text begins with "…groundwater inputs may be critical…" and in turn on page 5-21 in the first full paragraph, the topic sentence begins "…groundwater-influenced stream flow…likely benefit fish…" Both deal with the same topic. Hence, these two paragraphs could easily be combined, serving to shorten the text, reduce redundancy, and improve readability.
5-22		Similarly, the text on page 5-22 includes citations (at the end of the same sentences) to both sections and tables and figures in Chapter 4. This suggests to me that the text is not only overlapping, it is redundant and better overall report organization would serve its presentation well.
5-23	Table 5-5	Some explanation in the table title would benefit the reader, as to where these gages are placed in the stream. The labeling is arcane at best UT100D; letters suggest Upper Talarik Cr., but what is 100D. Now, I figured out from text that the first ones were high in the watershed and then they proceeded downstream (increasing drainage area gave me a hint as well). Use better descriptors (such as SK1 through SK5 from low to high stream order) or explain the ones that are being used.
5-26	Table 5-7	I cannot find any bold in this table that would reflect the pre-mining condition. Is that the same column as "Pre-Mining" as it is in Table 5-8 on page 5-34 (and the next few tables as well)?
5-27		Cite Figure 5-8 in text any time the stream gages are mentioned. The reader then has the ability to easily refer back to stream gage locations.
5-32 to 5-39		How do these tables and figures differ? Might they be 10% reduction in flow, 11-20% reduction inflow and >20% reduction in flow, as suggested in text? If so, then these table and figure titles need to reflect this information and be better described in the legends of the figures. Finally, do we need both tables and figures?
5-31		The Richter et al. (2011) reference, which underpins this section is incomplete in the Literature Cited (Chapter 9), suggesting only March as the publication date. Update in any revision.
5-31		It should be made clear that the Richter et al. (2011) sets quite specific bounds for all rivers regarding ecosystem function and does not provide any specific insight into salmon production (made somewhat clear in the last sentence of the next to the last paragraph on page 5-43). I think an additional caveat stating this explicitly on page 5-31 would improve the text.

Roy A. Stein, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-46		Stream flow losses due to the mine footprint are discussed first as underestimated, then as overestimated, and then a conclusion that they are underestimated (i.e., because the mine will need more water than is available from surface run-off). If this is the case, why go through the other scenarios…to seem even-handed? I am not sure all of this text is required.
5-46		Mine start-up will require more water than is available from the footprint of the mine itself. Hence, water will be captured from other streams than just those associated with the mine, which will influence stream flow and groundwater supplies. Are there estimates of the amount beyond the surface water that will be required?
5-53 to 5-58		I am a little confused by this section. The implication throughout is that copper toxicity will be based on the response of aquatic invertebrates (which would then be protective of direct effects on salmon). However, near the end of this section, there is a discussion about zooplankton being most sensitive and a comment about the reliance of juvenile sockeye rearing in lakes on these zooplankton. Yet, there is no resolution of what criteria will be used for toxicity values…will it be aquatic invertebrates or the more sensitive zooplankton? Clarification is required here.
5-59		"Discharge permits for mine in the Bristol Bay watershed should include relevant whole-effluent toxicity testing and monitoring of biotic communities in receiving streams". Does this quote solve the problem mentioned in the previous comment? Is this a realistic expectation for mine operators before permits are issued?
5-68	Table 5-22	>10% rather than <10% in the table title.
Chapter 6		Rivers is lower case when multiple rivers are listed.
6-1		Why assume that only 20% of the tailings stored would be mobilized with any dam failure? Is there a justification for this important assumption? Yes, see Appendix I, page 14 for citation to Dalpatram (2011); this should be cited in the main report in Chapter 6.
6-4		Add map showing the impact of the failed TSF 1, i.e., distribution of sediments and impact downstream.
6-42		The sentence in mid-paragraph (3rd complete paragraph on this page) "…multiple failures such as might occur…" My guess is that an example should follow the phrase "such as."
7-2		The sentence at the end of the last full paragraph on the page makes little sense: "The overall consequences are diminished and extinct salmon populations."
8-6	2nd complete par., last sentence	"further" should be "farther"; sorry, I just couldn't help myself…

William A. Stubblefield, Ph.D.

None.

Dirk van Zyl, Ph.D., P.E.

NOTE: I have indicated a number of specifics in the text above and do not have any others to list.

References:

Aziz, M. and Meints, C. 2012. Goldcorp Canada Ltd. – Equity Division Environmental Report 2011.

Blight. G.E. and Fourie, A.B. 2003. A Review of Catastrophic Flow Failures of Deposit of Mine Waste and Municipal Refuse. In L. Picarelli (ed.). Proceedings of the International Workshop on Occurrence and Mechanisms of Flow-like Landslides in Natural Slopes and Earthfills, Sorrento, Italy. May 14-16.

EPA. 1998. Guidelines for Ecological Risk Assessment, Risk Assessment Forum, EPA/630/R-95/002F, April.

EPA. 2003. Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment, Risk Assessment Forum, EPA/630/P-02/004F, October

Fretz, N.; Momeyer, S.; Neuner, M.; Smith, L.; Blowes, D.; Sego, D. and Amos, R. 2011. Diavik waste rock project : unsaturated water flow, Tailings and Mine Waste 2011: Vancouver, Canada, http://hdl.handle.net/2429/38058, 9pp.

Furniss, M.J., Roelofs, T.D. and Yee, C.S. 1991. Road construction and maintenance. Pages 297-323 in W. R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19.

Ghaffari, H., Morrison, R.S., Deruijeter, M.A., Živković, A., Hantelmann, T., Ramsey, D. and Cowie, S. 2011. Preliminary Assessment of the Pebble Project, Southwest Alaska, Preapred for Northern Dynasty Minerals Ltd., February 15, Wardrop (A Tetra Tech Company), Vancouver, BC, Accessed on www.sedar.com under Northern Dynasty.

Governor's Salmon Recovery Office. 2008. State of the salmon in watersheds report. Governor's Salmon Recovery Office, Olympia, Washington. (Quoted in Price, et al. 2010).

Harris, H.J., Wenger, R.B., Harris, V.A. and Devault, D.S. (1994) A method for assessing environmental risk: a case study of Green Bay, Lake Michigan, USA. Environ Manage 18(2):295-306. (Quoted in EPA 1998).

International Electrotechnical Commission (IEC). 2009 Risk Management - Risk Assessment Techniques, IEC/FDIS 31010:2009(E), 92 pp. http://www.previ.be/pdf/31010_FDIS.pdf Accessed July 28, 2012.

Kaplan, S. and Garrick, B.J. 1981. On the quantitative definition of risk, Risk Analysis, Vol. 1, No. 1, pp. 11-27.

Minera Panamá. 2012. Mina de Cobre Panama – Basic Engineering Summary Report, May, 140 pp.http://www.inmetmining.com/Theme/Inmet/files/pdf/2012/Cobre%20Panama%20BESR%20-%20Rev%20B_v001_l9917m.pdf, Accessed July 28, 2012.

Morgenstern, N. R. 2010. Improving the safety of mine waste impoundments. In: Tailings and Mine Waste '10: Proceedings of the 14th International Conference on Tailings and Mine Waste, Vail, CO. October 17-20, 2010. CRC Press, Boca Raton FL, pp 3-10.

Nichol, C., Smith, L. and Beckie, R. 2003. Water flow in uncovered waste rock: A multiyear lysimeter study, Proc., 6th Inter. Conf. on Acid rock Drainage, Cairns, Aust, pp. 919-926.

National Research Council (NRC). 2009. Science and Decisions – Advancing Risk Assessment, Washington DC: National Academy Press.

Price, D. M., Quinn, T., and Barnard, R.J. 2010. Fish Passage Effectiveness of Recently Constructed Road Crossing Culverts in the Puget Sound Region of Washington State. North American Journal of Fisheries Management 30:1110-1125.

Robertson, A. and Shaw, S. 2012. Failure modes and effects analysis (FMEA), Infomine, http://technology.infomine.com/enviromine/issues/cls_fmea.html Accessed July 29, 2012.

Znidarčić, D., Miller, R., Van Zyl, D., Fredlund, M. and Wells, S. 2011. Consolidation testing of oil sand fine tailings, Tailings and Mine Waste 2011: Vancouver, Canada, http://hdl.handle.net/2429/38782, 7 pp.

Phyllis K. Weber Scannell, Ph.D.

Page	Paragraph or Line #	Comment or Question
Page 4-11		The document states "geomembranes are generally estimated by manufactures to last 20 to 30 years when covered by tailings (North pers. comm...)." Unless North is a P.E. with experience in geomembranes, the statement needs a stronger reference. For example, Erickson et al (2008)* discuss the quality issues with geomembranes related to manufacture, installation and application of a soil-based cover (such as bentonite).
4-23	1	This first sentence is confusing and implies that oxygen has low solubility because it is in the tailings pond. Suggested change: eliminate the first phrase "In a TSF".
6-36	P 3	Last sentence states: [water] treatment would continue until institutional failures ultimately resulted in abandonment of the system, at which time untreated leachate discharges would occur. This statement is not supported by any documentation and is not clear what is being implied. Failure of governments? As stated in my response to questions, any mine plan must include sufficient bonding and plans for reclamation, including necessary water treatment.
6-37	P 4	End of paragraph states "premature closure could leave waste rock piles in place." Again, there is a need for plans for mine closure, concurrent reclamation and sufficient bonding.

Phyllis K. Weber Scannell, Ph.D.

Page	Paragraph or Line #	Comment or Question
App. G, Page 5	P1, last line	Document states: "…other short road segments connect Dillingham to Aleknagik and Naknek to King (Figure 1)." Shouldn't King be King Salmon?
App. G, Page 5	P3	Dolly Varden should be capitalized throughout the document. The list of fish species should contain scientific names or reference a table of common and scientific names. The document states "In the most comprehensive published field inventory, Woody and O'Neal (2010) reported." Because the authors have not reviewed other documents on field inventories, the phrase "most comprehensive" should be changed to "a comprehensive"

***** Erickson RB, Thiel RS and Peters J. 2008. The Ongoing Quality Issues Regarding Polyethylene Geomembrane Material Manufacturing & Installation. The First Pan American Geosynthetics Conference & Exhibition. 2-5 March 2008, Cancun, Mexico.

Paul Whitney, Ph.D.

A lot of page and paragraph comments are included the above responses to charge questions. I have no further comment.

REFERENCES:

Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2000. Pacific salmon and wildlife - ecological contexts, relationships, and implications for management. Special Edition Technical Report, prepared for D.H. Johnson and T.A. O'Neill (Manag. Dirs.), Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia, Washington. 141 pp.

Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2001. Pacific salmon and wildlife: ecological contexts, relationships, and implications for management. Pp. 628-685 in: D. H. Johnson and T. A. O'Neill, ed. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis OR. pp.

Cordes, L. 1975. Vegetation change in the Peace-Athabasca Delta 1970 – 1974. Department of Indian Affairs and Northern Development. Government of Canada, ON. Canada.

Doucet, R., J. Marks D. Blinn, M. Caron, and B. Hungate. 2007. Measuring terrestrial subsidies to aquatic food webs using stable isotopes of hydrogen. Ecology, 88:1587-1592.

EPA. 1999. Consideration of impacts in EPA Review of NEPA documents. USEPA. Office of Federal Activities (2252A) EPA 315-R-99-002/May 1999.

Gende, S. T. Quinn, M. Willson, R. Heintz and T. Scott. 2004. Magnitude and fate of Salmon Derived Nutrients and Energy in a coastal ecosystem. Journal of Fresh Water Ecology 19:149-160.

Gende, S., R. Edwards, M. Willson, and M. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. Bioscience 52:917-928.

Hilborn, R. 2005. Are sustainable fisheries achievable? In Science of maintaining the sea's biodiversity. eds. Norse, E., L. Crowder and M. Soule. Island Press.

Holling, C. editor. 1978. Adaptive environmental assessment and management. John Wiley & Sons, New York.

Johnson, D and T. O'Neil. 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis OR.

Koerner, R., Y. Hsuan, G. Koerner. 2005. Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions, GRI White Paper #6. Geosynthetic Institute Folsom PA.

Lackey, R. 2001. Values, policy, and ecosystem health. Bioscience 51:437-443.

Lee, D. 1996. Effects of the eruption of Mount St. Helens on physical, chemical, and biological characters of surface water, ground water and precipitation in the Western United States. U.S. Geological Survey Water-Supply Paper 2438.

Lee, D. and B. Rieman. 1997. Population viability assessment of salmonids by using probabilistic networks. North American journal of fisheries management 17:1144-1157.

Liberato, S., M. Coll, S. Tudela, I. Polomora and F. Pranovi. 2008. A new index to qualify the ecosystem impacts of fisheries as removal of secondary production. Ecology Progress Series 355:107-129.

Marcot, B., C. Allen, S. Morey, D. Shively and R. White. 2012. An Expert Panel Approach to Assessing Potential Effects of Bull Trout Reintroduction on Federally Listed Salmonids in the Clackamas River, Oregon, North. American Journal of Fisheries Management 32:3, 450-465.

McCarthy, S., J. Incardone and N. Scholz. 2007. Coastal storm, toxic runoff, and the sustainable conservation of fish and fisheries. American Fisheries Society Symposium 64:1-21.

McElhany, P., E. Steel, K. Avery, N. Yoder, C. Busack, and B. Thompson. 2010. Dealing with uncertainty in ecosystem models: lessons from a complex salmon model. Ecological Applications 20:465–482.

Morrison M., B. Marcot and R. Mannan. 1998. Wildlife Habitat Relationships. The University of Wisconsin Press.

Pauly, D., V. Christensen, and C. Walters. 2000. Ecopath, Ecosim and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES Journal of Marine Science 57:697-706.

Ruhl, J. and R. Fischmann. 2011. Adaptive Management. Minnesota Law Review 95:424-484.). http://www.minnesotalawreview.org/wp-content/uploads/2011/07/Ruhl-Fischman_MLR.pdf.

Schlosser, I. and L. Kallemeyn. 2000. Spatial variation in fish assemblages across a beaver influenced successional landscape. Ecology 81: 1371-1382.

Snodgrass, J. and G. Meffe. 1997. influence of beavers on stream fish assemblages; effects of pond age and watershed position. Ecology 79: 928-942.

Woolington, J. 2009. Caribou management report of surveys-inventory activities July 2006 – June 2008. Alaska Department of Fish and Game, Juneau, AK.

APPENDICES

APPENDIX A: EPA'S SUMMARY OF PUBLIC COMMENTS

BRISTOL BAY ASSESSMENT PUBLIC COMMENTS
Summary for Peer Reviewers

This document provides a brief overview and summary of the public comments received by the U.S. Environmental Protection Agency (EPA) during the public comment period for its draft assessment entitled *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska* (hereafter, the Assessment). This summary focuses particularly on those comments addressing scientific or technical aspects of the draft Assessment. It was prepared by EPA staff for Versar, Inc., solely to assist the Bristol Bay scientific peer reviewers in preparation of their reviews of the Assessment. It is not meant to be comprehensive or detailed, and is not intended to provide any analysis of or commentary on the comments provided. A few clarifying notes by the EPA are presented in square brackets, but no attempt was made to systematically address the issues raised.

All of the public comments received on the draft Assessment are publically available on regulations.gov, under docket number EPA-HQ-ORD-2012-0276. Peer reviewers also will be able to access the public comments directly via a dedicated FTP site; instructions on how to access this site will be provided by Saturday, August 4 at 5:00 PM ET. In addition, transcripts from eight public meetings held by the EPA in Seattle, Anchorage, and throughout the Bristol Bay region are accessible via regulations.gov and will be placed on the FTP site. Further detail on any of the issues outlined in this summary can be found in these letters and public transcripts, and the EPA encourages peer reviewers to consult these resources as needed.

Overview of Public Comments

The EPA received over 220,000 public comment letters on the draft Assessment. This total includes approximately 5,500 unique letters and approximately 215,000 letters from twenty-five different mass mailing campaigns. Nineteen of these mass mailing campaigns, generating approximately 209,000 letters, expressed support for the Assessment and/or EPA action. Five campaigns, generating approximately 5,400 letters, were not supportive of the Assessment and/or EPA action. The remaining mass mailer, signed by 318 people, requested a comment period extension.

The comments received reflected a wide variety of viewpoints both supportive and critical of the Assessment. The vast majority of comments supported the conclusions of the Assessment and noted that the science demonstrates that a large-scale hardrock mine in the Bristol Bay watershed would jeopardize the salmon fishery the region supports. Other commenters stated that the Assessment is scientifically deficient and does not support that conclusion, and that large-scale mining can occur in the Bristol Bay watershed without significantly damaging existing salmon populations.

Many commenters who generally endorsed the conclusions of the Assessment felt it has underestimated the risk and impacts associated with large-scale mining in the Bristol Bay region. Commenters expressed a desire to expand the scope of the Assessment, for example by including impacts of related development and effects on additional species. A more detailed list of suggested scope expansions can be found below, particularly in the Chapter 3 section. Other commenters suggested additional scientific information that should be incorporated into the Assessment, including studies on seismic hazards and environmental impacts at other mines.

Commenters who stated that the Assessment is scientifically deficient criticized it for considering the potential impacts of a hypothetical mine scenario, rather than a proposed mine plan, and for overestimating the risks and impacts associated with that scenario. In designing the hypothetical mine, some commenters stated that the Assessment does not rely on the most current practices and ignores existing standards and regulatory requirements for the design of tailings dams, waste rock piles, water treatment and management plans, road and culvert design, pipelines, and mine closure activities. These comments stressed that the mine permitting process would require avoidance, minimization, and mitigation of impacts, and that the Assessment should reflect potential benefits of these mitigation and remediation activities and be consistent with current practice and regulatory requirements. Commenters also requested that the EPA expand its consideration of the Environmental Baseline Data collected by the Pebble Limited Partnership, noting that it is a significant data source that is under represented in the Assessment.

Non-Technical Comments

Although non-technical comments are not the focus of this summary document, general consideration of these comments is informative—largely because most of the comments received did not focus on technical issues raised by the draft Assessment. In this section, we provide a brief overview of some of the common non-technical issues raised in the public comments.

Many commenters focused on the importance of a functioning ecosystem, and particularly a robust salmon fishery, to the region, in terms of subsistence use, Alaska Native culture, commercial and recreational fisheries, and tourism. Other commenters stressed the potential economic benefits of mine development to this economically depressed region.

Nearly all commenters discussed Section 404(c) of the Clean Water Act and EPA's authority to restrict, prohibit, deny, or withdraw the use of an area as a disposal site for dredged or fill material, if the discharge will have an unacceptable, adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas. A majority of commenters urged EPA to proactively use this authority to protect the Bristol Bay watershed by pursuing a 404(c) veto, given the conclusions of the Assessment and the ecological and cultural resources of the Bristol Bay region. However, other commenters stated that the Assessment does not support such an action, and that EPA should defer any regulatory decision until a permit application for a specific mine project has been submitted and a thorough study of potential impacts has been completed, as part of an Environmental Impact Statement required under the National Environmental Policy Act.

Summary of Comments Organized by Assessment Chapter or Appendix

This section provides a summary of the technical, scientifically substantive public comments received on the EPA's draft Bristol Bay Assessment, organized by the relevant chapter or appendix of the Assessment. Comments related to other aspects of the draft Assessment, such as potential regulatory actions, are not included in this summary, but can be viewed via regulations.gov or the FTP site.

Chapter 1. Introduction/General

- Issues concerning use of the Pebble Limited Partnership's (PLP's) Environmental Baseline Document (EBD)
  - Data from the EBD should not be used because its methods are invalid and species are misidentified.
  - More data from the EBD should be incorporated throughout the Assessment.
    - Assessment cites EBD 71 times, but it is highly unlikely that all available information in the 27,000 page EBD was incorporated.
- Issues concerning the Assessment and established methodologies and guidelines
  - Assessment is not an ecological risk assessment because it does not follow EPA's 1998 risk assessment guidelines.
  - Assessment inappropriately used EPA's 1998 risk assessment guidelines, which are more appropriate for smaller-scale studies with identified sources, pathways and receptors in a clearly defined area.
  - Assessment was developed using no clear or established methodologies.
  - Ecological risk assessment approach is inappropriate without baseline data and actual mine design parameters.
- General data and information quality issues
  - Much of the assessment fails to meet the requirements of the Federal Data Quality Act, because assumptions were made regarding impacts that are not supported by existing literature.
  - Data used in assessment are not representative, complete, or current.
  - ADF&G has many additional sources of fisheries data that were readily available but not considered.
  - Citation issues
    - Assessment should provide more citations.
    - Assessment uses outdated references.
    - Assessment demonstrates selective bias in the data and information used.
- Other general issues
  - Assessment is too general and speculative, not detailed enough, and does not present results scientifically.
  - Assessment lacks knowledge of the mining industry and Alaska's permitting and regulatory framework.
  - Assessment provides contradictory and conflicting information.
    - For example, conclusions in the Executive Summary (ES) are not supported by the body of the document (e.g., ES states probability of failure of collection and treatment systems is high, but Chap 6 says can't be estimated from the data and highly uncertain).
  - Assessment is scientifically sound and provides reasonable assessment of risks posed by large-scale hardrock mining in the Bristol Bay watershed.

- Environmental and habitat impacts have been grossly overstated.
- Assessment focuses on mine failures rather than mine successes.
- Qualitative assessment ratings are not clearly defined, including the use of "significant" and "highly likely".
- Consideration of subsistence values should be more thoroughly and prominently discussed throughout the Assessment, given that subsistence resources and activities play an invaluable role in Alaska Native cultures.
- The Pebble project should not be used as a surrogate for other mining operations in the Bristol Bay watershed, as it is not the largest and has different deposits.
- Although the assessment underestimates the risks from mine operation, the estimated risks exceed those in all prior 404(c) actions.

Chapter 2. Characterization of Current Condition

- Fish resources
  - Assessment appropriately characterizes importance of the Bristol Bay fishery (economically, ecologically, and culturally).
  - Detailed discussion of salmon life history and ecology is missing from the Assessment. Do not simply cite the appendices.
  - Extent of anadromy for Dolly Varden and rainbow trout is poorly understood for the region and should be better characterized in the Assessment.
  - Naknek River sockeye are included in the numbers of fish from the Kvichak River, but the Naknek is not part of the study area; thus, including those fish overstates production in the Kvichak River.
  - Lake and beach spawning should not be mentioned because it does not occur on the Pebble site (with the possible exception of Big Wiggly Lake).
  - The importance of Bristol Bay salmon relative to global stocks should not be mentioned.
  - Salmon stocks are influenced by management rather than by habitat.
  - The evaluation of risk throughout the document needs to be expanded to include all salmon species and life stages.
  - The productivity of streams near the Pebble deposit is exaggerated, and should be compared to all other streams in the Bristol Bay watershed.
  - Marine-derived nutrients are not important on the Pebble site.
  - Assessment's estimates of marine-derived nutrients in returning salmon are incorrect.
  - General statements from the literature about the influence of groundwater on salmon habitat should not be used unless they have been demonstrated at the Pebble site.
- Alaska Native cultures
  - Assessment should discuss that commercial fishing no longer provides enough money to supplement a subsistence way of life, and additional employment is needed (also included under Appendix D).
  - Assessment should discuss that population is not stable: the Lake and Peninsula Borough has lost over 18% of its population since the 2000 census, and schools have been lost in Ivanof Bay and Pedro Bay due to low enrollment (also included under Appendix D).
- Other resources
  - Terrestrial bird fauna are adequately described,
  - Marine and coastal bird fauna are inadequately described, and Assessment should discuss Bristol Bay's globally significant bird habitats

  - EPA's conclusions on vegetation are sound because they are supported by sources of information other than PLP's EBD.
- Other general issues
  - Assessment should stress that water in the region far exceeds virtually all of the State of Alaska's water quality standards, increasing the likelihood that aquatic life will be highly susceptible to increases in metal concentrations.
  - Assessment should provide a more defensible and objective characterization of baseline conditions, including how indigenous resource systems often play important roles in the biocomplexity and stability of ecosystems.
  - Pebble EBD studies are not cited a single time in this chapter, although they provide in-depth studies of current conditions.
  - Assessment needs to do better job of explaining and presenting the portfolio effect and aspects of salmon quality and diversity.
  - The analysis of habitat complexity in the Wood, Nushagak, and Kvichak River watersheds is not applicable to the assessment because it does not address the Pebble site in particular.
  - The stability of river flows in Bristol Bay should not be compared to those in other salmon-producing areas.
  - Rivers that merge in their estuarine reaches should not be considered to have a common watershed.

<u>Chapter 3. Problem Formulation</u>

- Scope of the Assessment should be expanded to include:
  - Secondary development
  - Electrical generation
  - Block caving
  - Blasting (as source of nitrate and ammonia)
  - Dust production
  - Chemical spills
  - Fuel spills
  - Tailings pipeline spills
  - Waste rock slides
  - Climate change
  - Noise pollution
  - Port at Cook Inlet and associated facilities
  - Direct effects of mining on human health
  - Direct effects of mining on wildlife (including freshwater seals in Iliamna Lake)
  - Entire Bristol Bay watershed, including marine areas
  - Impacts to drinking water sources within the Nushagak and Kvichak River watersheds
  - Risks to all Alaskans (not just Alaska Natives), including those engaged in commercial, personal use, sport, and subsistence fisheries and hunting
  - Socio-economic impacts
  - Effects on all important fish species (including black fish that inhabit swampy marshland around Iliamna Lake)
  - Invasive species issues (e.g., invasive plants)
  - All mining prospects in the Bristol Bay watershed
  - Potential benefits of mine development to human health, safety, welfare, and the environment

- Other issues
  - Assessment uses an inconsistent scale and scope of the project area (Bristol Bay, the Nushagak and Kvichak River Watersheds, the tributary headwaters at the Pebble site, the Pebble site itself), and fails to address or quantify potential impacts as they relate to the various scales (e.g., should put length of stream lost in context of the entire watershed).
  - Assessment fails to address or quantify potential impacts as they relate to the various scales.
  - Assessment should state that it is necessarily incomplete because it is bounded by the scope of its mandate.
  - Fraser River should not be used as an analogous watershed.
  - Not all pathways shown in the conceptual models are analyzed in the Assessment.
  - Not all relevant pathways are included in the conceptual models.
  - Rainbow trout should be considered as salmon, since they are in the same genus.
  - Consider cultural ties to area fisheries resulting from multi-generational use by commercial, sport, and non-Native subsistence fishers.

Chapter 4. Mining Background and Scenario

- Tailings storage facility (TSF) failure issues
  - Run-out from TSF failure should be modeled based on Rico et al. (2008), resulting in 38% of tailings spilled rather than the conservative 20% value.
  - The assumption that 20% of tailings could spill is too high.
  - Failure rates for historic dams should not be considered.
  - The assumption of a probable maximum flood is too extreme.
  - It is unreasonable to assume that sufficient freeboard to contain the probable maximum flood would not be maintained.
  - Probability of TSF failure is overestimated because estimates are based on historic failure rates.
  - Probability of TSF failure is underestimated because estimates are based on design specifications.
  - Any failed tailings dam would be repaired and remediation would be immediate, so impacts of failure are overestimated.
  - The only logical, albeit still unreasonable, full-volume TSF failure scenario is to have failure occur at the southern embankment.
  - The modeling results for the tailings spill scenario are incorrect, because the tailings could be deposited in the first 30 km given valley volume.
  - The Silva et al. method should not be applied to hypothetical dams.
  - Assessment's description of tailings particle size is inconsistent.
  - Tar sands tailings compaction is not proven to be similar to mine tailings compaction.
  - Assessment's assumption of a void ratio of 46% filled with unrecoverable water is within range of reported values in literature, but is likely to be inaccurate.
  - "Sloping" of bulk tailings has not been effective in preventing tailings release in other dam failures, since tailings often saturated long-term.
- Water budget and hydrology issues
  - Assessment's water budget is suspect, unreliable, and not realistic.
  - The assessment seriously underestimates the amount of water that would require collection and treatment.

  - The hydrologic water balance (Table 4-5) contains a gross error because it shows the same pore water volume during different periods [NOTE: commenter mistook a use rate (m^3/yr) for the volume in use (m^3)].
  - Assessment ignores the fact that hydrology depends on location characteristics.
  - Figure 4-7 should not show streams that are not important to the endpoint fish species.
  - Box 4-2 presents a brief and vague discussion of effects of the cone of depression, which should include discussion of mitigation.
  - Assessment evaluates water flow and hydrologic impacts during average rather than low flows.
- Water quality and treatment issues
  - Assessment should discuss, at least in a general sense, possible types of water treatment needed and whether these types of treatment have been used at other mines with similar volumes of discharged water.
  - Discussion of tailings leachate chemistry in the Assessment does not seem to consider humidity cell test results from the one pyritic tailings humidity cell test sample.
  - It should not be assumed that acid generation would stop below the water level in the open pit after closure.
  - Assessment should include movement of contaminated mine water from the pit or underground workings to downgradient streams and groundwater.
  - Assessment should consider how other wastewaters (beyond mill waste tailings) could affect downstream water quality, for both no failure and failure modes.
  - Assessment should evaluate how natural stream waters will change from discharge of treated mine water under no failure mode (e.g., increase in water hardness and potential impacts, even if water quality standards are met).
  - Assessment should consider oxygenation of tailings by upwelling groundwater.
  - All major mines in Alaska operate with a mixing zone. If the EPA believes that the water from the mine can be treated to meet standards without a mixing zone it should cite a relevant case in which that was achieved.
  - The assessment does not adequately consider the need to collect and treat peak flows due to extreme events.
  - The difficulty of adequately treating the discharge water from a pit lake to achieve water quality criteria at end-of-pipe is underestimated. In particular, the freezing conditions during 7/12 months are not considered.
  - The assessment does not recognize the difficulty of capturing the leachate from tailings impoundments given the porous and fractured geology of the site.
- Seismicity issues
  - Assessment overstates the strength of current scientific knowledge of seismic risks in the area, implying that lack of evidence from past earthquakes is evidence that no such earthquakes have ever occurred.
  - Very little research has been done on seismic hazards in this region and the seismic hazard assessment presented in PLP's Environmental Baseline Document is flawed, so uncertainty is high.
  - There is not a high degree of uncertainty concerning the location and future activity of geological faults.
  - Assessment should emphasize the lack of evidence of recent faulting near the Pebble site and the expectation that a mine operator would mitigate against seismic risks.
  - Assessment fails to reference the most current and appropriate publication on the largest nearby fault, Koehler and Reger 2011.
  - Assessment's concern that earthquakes pose a potential danger is well-founded.

  - Assessment does not describe the general seismic environment of Bristol Bay and is missing the broader geological context of four independent and actively moving blocks of crusts and subduction.
  - The terminus and length of the Lake Clark fault have not been determined.
  - Assessment should describe the lack of effects at the Fort Knox tailings dam due to the 2002 earthquake on the Denali fault.
  - Quake proximity is equally important to magnitude in designing embankments. One located closer than that used in PLP's design assumptions (i.e., 18 miles from the site) could produce significantly more energy.
  - Provide more details concerning seismicity.
- Road and pipeline issues
  - Assessment's assumption of standard road and stream crossing designs is not sufficiently specific.
  - Road design and maintenance are not clear.
  - Failures of the Trans Alaska Pipeline are not relevant because they were due to human failures in inspection and management.
  - The volume of product spilled in a pipeline failure is overestimated, because shutdown would reduce flow rate.
  - Assessment should mention that 15-20% of the proposed road already exists.
  - Assessment does not adequately address potential mitigation for effects of roads due to sediment, salts, dust, and interference with surface and shallow groundwater flows.
  - Construction of a road or pipeline should not be assumed.
  - Oil and gas pipeline failures rates should not be considered.
  - Modern culvert standards should be assumed.
  - Modern mine roads do not inhibit fish passage.
  - Include risks from bridges.
- Geological issues
  - Porphyry copper is not the major mineral resource type in the Nushagak and Kvichak watersheds
  - Assessment contains inadequate discussion of geology and hydrogeology of the Pebble area, especially in the pit and tailings storage facilities.
  - Assessment's description of porphyry copper deposits is not relevant because each deposit is unique and some mineral deposits in the Bristol Bay watershed are not porphyry copper.
- Design, mitigation, remediation, and restoration issues
  - The document fails to address impact avoidance, minimization, or mitigation actions, thereby overstating potential impacts.
  - All of the failures considered in the Assessment can be avoided by proper design, so no failures should be assumed.
  - Effective mine closure measures ensure no contamination impacts downstream.
  - Assessment does not adequately consider the application of midwestern coal mine reclamation and other techniques for habitat mitigation post-closure.
  - Assessment should discuss that scientific literature documents that stream restoration has generally been unsuccessful.
  - Assessment fails to address challenges and risks of mitigating stream and wetland losses.
  - Assessment does not adequately address challenges of constructing and operating a failure-proof mine with respect to water treatment

  - Assessment does not address challenges and feasibility of post-closure reclamation given scale and climate.
  - It is unrealistic to consider any mine closure that does not include planned site management, given state reclamation bonding requirements.
  - Assessment should include significant data on geomembrane service life that are available from mining and other industry or government sources.
  - Alaska bonding requirements will assure perpetual monitoring and maintenance, and should be described in Assessment.
  - A spillway would be installed after closure.
  - Present or reference information such as permafrost distribution, slope, aspect, surficial materials stability, etc., for evaluation of impacts from roads, pipelines, failiures, etc.
  - The tailings and waste rock are likely to be hazardous materials that would require lined storage.
  - The assessment does not adequately address the difficulty of reclaiming the waste rock piles and tailings impoundments including the availability of suitable cover to support revegetation.
  - Block caving issues:
    - Address fact that block caving would fracture overlying strata, allowing water and oxygen infiltration into mine. After closure, such infiltration could lead to down-gradient contamination.
    - Address whether block caving would require dewatering similar to open pit mining.
    - Identify monitoring and other post-closure issues unique to underground mining.
- Assessment underestimates potential effects because:
  - Underestimates maximum size of potential mine (6.5 billion tonnes vs. 10.8-11.9 billion tonnes estimated).
  - Groundwater effects are highly uncertain
    - Assessment assumes tailings storage facility and valley walls are impermeable and that seepage will follow current topography
    - Does not consider how DO saturated water upwelling into tailings storage facilities can be alleviated.
  - Does not consider cumulative impacts associated with build-out of a single mine, including power, port, transportation, other infrastructure development.
  - Given performance record of existing mines, there is a significant chance that one or more of the failures evaluated will happen over the life of the mine.
  - Uses National Wetlands Inventory, which vastly underestimates wetland extent.
  - Uses Alaska NHD, which underestimates extent of streams.
  - There is no evidence of any industry or society successfully collecting, pumping, and treating mine wastes for tens of thousands of years, as must be done here.
  - Does not include all necessary components of mine footprint.
  - Water balance underestimates volume of water needing treatment during operation and post-closure.
  - Fails to account for extreme events (e.g., peak storm runoff).
  - Fails to account for porous nature of surficial deposits and fractured bedrock under tailings impoundments.
  - Fails to note that enormous wastewater discharges can only take place during 5 months of year when receiving waters are not frozen.

  - Failure scenarios are too conservative, and should be revised to better reflect worst-case scenarios.
  - Seepage collection systems are notoriously inefficient, if not ineffective, often resulting in long-term contamination of down-gradient waters.
- Assessment overestimates potential effects because:
  - Mine size is overestimated.
  - Deposition in Iliamna Lake would be less consequential than assumed.
  - Wet disposal of tailings behind a dam should not be assumed.
- Other issues
  - The Assessment does not provide an accurate assessment of potential mine development impacts, because the hypothetical mine and scenarios are not the only options available in the Bristol Bay region.
  - The assessment's hypothetical mine scenario accurately represents the potential for mining in the Bristol Bay watershed.
  - The copper concentrate would be alkaline and dissolved copper concentrations in the slurry would be low.
  - The Pebble deposit is not located in the headwaters of the Nushagak and Kvichak Rivers, but the headwaters of tributary streams.
  - The Gibraltar Mine in British Columbia has thriving populations of rainbow trout in both its active tailings pond and its seepage control and pump-back pond.
  - Premature closure would not occur because it is against State policy.

Chapter 5. Risk Assessment: No Failure

- Because the size of the mine resource is underestimated, the assessment underestimates long-term risks to fish.
- Risks from contaminants are underestimated because:
  - Assumption that all water can be captured and properly treated to meet water quality criteria is spurious.
  - Laboratory toxicity tests for copper, and therefore State and Federal criteria, underestimate impacts to sensitive macroinvertebrates, algae, and olfaction-dependent behaviors in salmon (e.g., see McIntyre et al. 2012)
    - Most laboratory tests do not evaluate combination of low hardness and low dissolved organic carbon conditions seen in Bristol Bay headwater streams, which make biota even more sensitive to increased metal concentrations
    - Alaska and EPA copper standards are inadequate to protect aquatic life in study area, where increased metal concentrations will be toxic at very low levels.
  - Assessment should consider potential synergistic effects of mixtures (e.g., copper and zinc).
  - Truck traffic would be sufficient to make metals and oil significant stressors.
- Risks from contaminants are over-estimated because:
  - Copper toxicity is exaggerated; it is an essential element and is homeostatically controlled
  - A geologic analogue of Pebble near Williams Lake in British Columbia supports thriving populations of rainbow trout in both its *active* tailings pond and in its seepage pump-back pond.
- Risks from habitat loss or modification are underestimated because:
  - National Wetlands Inventory vastly underestimates wetland extent

    - Spot surveys of salmon may underestimate value of habitats at other times of year or under other conditions, thus underestimating importance of keeping these habitats connected
    - Effects are not dependent on the presence of salmon – changes in organic matter, invertebrates, and other fish species are critical to downstream salmon populations.
    - The ADEC temperature criterion of 13^{o} C is underprotective of spawning and rearing Dolly Varden.
    - Salmon populations and habitats are underestimated
        - Table 5.1, which reports PLP data for salmon spawner index counts, is based on an invalid methodology used by Pebble contractors (both the maxima and minima are underestimates).
        - Extent of anadromous habitat is underestimated because streams were not randomly sampled and existing sample site representativeness was not assessed.
- Risks from habitat loss or modification are overestimated because:
    - Mitigation of filled or altered streams and wetlands should be included.
    - The State of Alaska's data exaggerate the importance to salmon of streams near the Pebble deposit because presence may be interpreted as presence in abundance.
    - Many of the streams on the site are not ecologically functional and have poor habitat and water quality.
    - Water withdrawal would be mitigated.
    - Groundwater discharge should be considered as an alternative to surface water discharge.
    - Under a no failure scenario, water temperature would not be affected.
    - The assumption that stream flows downstream of the mine footprint would be reduced in proportion to the area of watershed reduced is not supported.
    - It should not be assumed that flow limits salmonid production because other unanalyzed factors also limit production.
    - Reduced flow could increase habitat by reducing velocity.
    - The mine footprint may not eliminate any streams or wetlands.
    - A majority of the stream channels in the vicinity of the footprint of the mine do not have off-channel habitat.
    - The Assessment fails to identify that food resources are a limiting factor to anadromous fish production in the mine footprint area.
    - Specific foraging opportunities or important rearing habitats with respect to juvenile salmon and wetlands are not presented in the Assessment.
- The assessment of roads and culverts is incorrect because:
    - Current culvert standards are not adequately considered
    - Published culvert failure rates are not relevant.
    - Current road standards are not adequately considered.
    - Although some wetlands will be filled or altered, the Pebble road alignment has been carefully planned to avoid or minimize these impacts, especially as they might affect fish or fish habitat.
    - The existing (and proposed) road alignment is not parallel to or in close proximity to that portion of Chinkelyes Creek to which sockeye (or any other) salmon currently have access.
    - The responses of salmonids to culverts are not uncertain; there are thousands of examples of the effects of culverts on salmonid fish passage in the Western U.S. and Canada alone.

- Much of the stream lengths upstream of the road are poor habitat or nonhabitat for salmon.
- $CaCl_2$ is not toxic.

- General hydrological comments:
  - The sustainability boundary method should not be used because it does not use relationships between biota and flow that are specific to the site.
  - Other methods for evaluating effects of streamflow regulation should be considered including: 1) Tennant/Montana Method, 2) Tow Width Method, 3) Wetted Perimeter, and 4) IFIM/PHABSIM.
  - Hydrologic analyses need to include sources of data, specific location of gages used, and more description in the methods.
  - The Assessment does not account for the reduction in evaporation due to the removal of vegetation and the duff layer that exists in the pre-mine condition. This would likely result in lower evaporation losses.
  - Mean annual flow is absolutely meaningless from an ecological perspective as related to fish production.
  - Section 5.2 attempts to quantify the impact that development may have on streamflow rates, but later acknowledges that it's not feasible to do so accurately.
  - The river continuum concept should not be applied to Alaska because it was developed in a different type of river.
  - Independent modeling indicates that the average annual alteration of stream flow estimated in the Assessment is supported by a more comprehensive model. However, consideration of temporal patterns of precipitation and climate suggests that hydrologic alteration would vary through the year, with short-term reductions in stream flow that greatly exceed the average reduction on an annual basis.
- General comments concerning fish:
  - Chum salmon do not rear in streams or rivers.
  - The assessment should explain why aerial counts are thought to underestimate the total run sizes.
  - There is no information regarding the genetics of the anadromous populations near the proposed mine site.
  - Spawning distribution maps do not match interactive maps from the Anadromous Waters Catalogue for Kaskanak and Upper Talarik, at a minimum.
  - The EPA should have evaluated the quantitative data presented at a Fish Technical Work Group meeting in 2008 and information from the 2004 Annual Progress Report for Fish and Aquatics for Northern Dynasty but not included in the Pebble Limited Partnership Environmental Baseline document.
- Assessment overestimates effects because in many instance EPA chose the most conservative measure, data, counts and indexes to determine potential impacts.
- Assessment should determine an average mine incident rate from other mines and violation records.
- Assessment should consider probable impacts of development on recreational fisheries and hunting.
- Assessment should include examples of large hardrock mines with wetland, stream, and fisheries impacts, especially if those impacts have been benign or offset by compensatory mitigation.
- Macroinvertebrate drift may not be diminished by the mine footprint.
- It is inconsistent to say that import of marine nutrients is important to the watershed and that export of nutrients from headwaters is important to downstream ecosystems.

- The length of streams lost in the mine footprint should be compared to the total length of streams in the entire watershed.
- The statement that "Projecting specific mining-associated changes to groundwater and surface water interactions in the mine area is not feasible at this time." is inconsistent with the conceptual model which shows that reduced groundwater input would be expected to increase summer temperatures and decrease winter temperatures.
- Discuss how water treatment would affect water quality even if it does not fail.

Chapter 6. Risk Assessment: Failure

- Comments about failures in general:
  - Assessment consistently underestimates and understates likelihood of failures and maximum impact expected under worst-case failure scenario.
  - Because size of mine resource is underestimated, the Assessment underestimates long-term risks to fish.
  - Assessment excluded some failures that were considered beyond scope: chemical spills, fuel spills, tailing slurry pipeline failures, rock slides.
  - Assessment should consider performance record of existing mines, including historical record of mine effects estimates and compliance issues.
  - Assessment confuses salmonids vs. salmon; because many salmonid taxa were not considered, threats to salmonids are greater than assumed in assessment.
  - Conclusion on failure rates is not supported by review of historical and currently operating mines, and is in contradiction to Alaska's record.
  - It should not be assumed that a reduction in salmon quantity or quality would affect salmon-based cultures. Mitigation should be assumed.
  - By placing doubt on the ability to operate in perpetuity, the Assessment creates an unrealistic standard that is impossible to meet.
  - Current mining practices such as those at the Red Dog mine are not appropriate representations of the potential for failures at the Pebble site.
  - The assessment neglects to account for continuous improvement in technology to mitigate failures.
  - The use of events at the Gibralter mine and Nixon mine as examples represents a bias.
  - The statement that a small fraction of Native Alaskans would be employed by the mine is incorrect.
- Tailings dam failure comments:
  - Impact of a major tailings pond failure is overstated, because immediate remediation is required under both state and federal law.
  - Current regulatory practice does not require financial assurance to cover dam failures or cleanup; securing such funding requires litigation and/or taxpayer support.
  - Dam maintenance will need to succeed for tens of thousands years, rather than hundreds.
  - Dam failure scenarios not realistic because:
    - The assessment examines scenarios where dams are not built to specification, which is not possible.
    - Examples of tailings spills include mining in the late 1800's and do not consider regulatory and engineering changes.
    - None of the examples are relevant to the regulatory and construction techniques expected to be applied.

- Assessment's use of the Mt. St. Helens eruption as an analogy to a tailings dam failure is unrealistic and unscientific.
- Mt. St. Helens demonstrates the resiliency of natural systems and potential for rapid recovery.
- Dam failure could affect estuarine ecosystem, which should be addressed.
- Risks of tailings storage facility (TSF) failure are underestimated by a factor of 10.
- Experience with other tailings spills indicate that the run-out distance would be much greater than the 30 km modeled by the EPA. Based on the run-out model by Rico et al. (2008), it would be about 460 km for the partial-volume failure and about 1800 km for the full-volume failure.
- TSF failure should be modeled for entire length of river to sea.
- TSF failure should model a 38% or 50% release rather than 20%.
- Lack of fish assemblage and population data severely limits model accuracy and likely produces gross underestimates of fish effects.
- Minimum effect levels for fine sediments may be 3-5%.
- Only one kind of dam failure is considered; if considered other types of failures, overall rates would increase.
- Assessment should model a 30-day precipitation period of 1 inch per day on saturated soils, as this may be a more common event.
- The HEC-RAS model is applicable and its limitations are appropriately presented.
- The analysis of effects of a tailings spill on wildlife is inadequate.
- Aside from some local scour that may occur in the immediate vicinity of the embankment, no scouring of the existing bed or valley bottom would be possible from a tailings spill.
- Tailings transport and deposition could not affect salmon use of the Mulchatna and Stuyahok Rivers.
- None of the causes of tailings dam failures listed in the ICOLD review are possible at the Pebble site.
- Tailings dams located 100 to 275 miles from earthquake epicenters did not fail during quakes.
- By providing specific analytical model results to describe the tailings flow distance and associated sediment deposition from a hypothetical tailings release, the Assessment dam breach analysis appears credible whereas in fact, the analysis is flawed.
- The choice of a value for Manning's friction factor is not adequately justified.
- The 30 meter digital elevation model is too coarse.
- The lateral extent of the cross-sections in the HEC-RAS model were likely insufficient.
- The extent of the sediment transport model should be extended to the river reach where the mine tailings are expected to be transported downstream (e.g. beyond the 30 km marker at the confluence of the North and South Koktuli Rivers).
- While the Hjulstrom curve is a widely used reference to evaluate sediment transport in streams, it is not well-equipped to be used to evaluate sediment settling in a dense, mostly solid flow such as the scenarios set forth in the Assessment.
- The contributing watershed area to TSF 1 is incorrect and this influences the comparative statistics.
- Ice scour and plowing should be included.
- The dilution of pore water by fresh water during a tailings spill would be trivial.
- Based on analogy to the Gibraltar mine, tailings pore water would not be toxic to fish.
- The fate of tailings in the Clark Fork River, Coeur d'Alene River and Soda Butte Creek is not relevant because the sources were different.

   - The discussion of copper leaching from tailings does not quantify the dilutions in the receiving streams.
   - The mobilization of metal enriched tailings by floods in the Coeur d'Alene River should not be mentioned because Cu was not a major toxicant.
   - The analysis of dietary copper toxicity is incorrect because copper is a micronutrient and is well regulated.
   - The persistence of metals in sediment depends on the metal.
   - The dietary chronic value for rainbow trout from the Pellston Workshop proceedings is biased.
- Pipeline failure comments:
   - Two-minute pipeline shutdown is reasonable only if safety measures work as designed. Evaluate scenario using data on average actual shutdown time, if available, as well.
   - Product concentrate spills would be remediated.
   - Threat of spills to Iliamna Lake nearshore spawners, zooplankton, and phytoplankton should be better considered.
   - The published histories of pipeline failure are not relevant.
   - The assumption of a constant pipeline failure rate is inappropriate.
   - In the product pipeline failure scenario, the assessors should assume more closely spaced shut-off valves at the locations of failures.
- Water collection and treatment failure comments
   - Assessment should better acknowledge high magnitude of water management challenges and potential for water management failures.
   - The assessment does not distinguish short term failures of water collection and treatment from those that would have significant off-site effects.
   - Text box 4-1 aggregates multiple worst-case failure scenarios into a single release event scenario which unreasonably overstates the probability of release due to a system failure in the water collection and treatment system. [NOTE: Actually, this box relates PLP's geochemistry results to potential on-site processes, and does not present failure scenarios.]
   - Significant water collection and treatment failures will not occur because of good management practices, if a reasonable time frame is considered (i.e., not perpetuity).
   - Passive management may be sufficient post-closure.
   - Failure of tailings leachate collection is unlikely and would be insignificant if it occurred.
   - The sorts of water treatment failures that are common are unlikely to have significant effects.
   - Inadequate designs of water treatment systems could no longer occur due to modern process engineering.
   - Assessment evaluates water quality and hydrologic impacts during average flow conditions, but because degree of dilution from receiving waters will vary seasonally, assessments based on averages are almost certain to underestimate water quality impacts under low flow conditions.
   - Independent modeling estimated that risks associated with failure of leachate collection from waste rock could include copper toxicity above water quality standards downstream at least to the middle Upper Talarik Creek, and to the junction of the North Fork and South Fork Koktuli rivers.
- Culvert and road failure comments
   - Likelihood of failures at stream crossings are greater than presented, because streambeds and wetlands are less stable than rock and more affected by floods.

- Modern culvert designs prevent failures.
- Unless evidence suggests otherwise, extent of wetland area, stream length, and salmon occupancy should be assumed to extend to the entire area.
- Statement that PLP's EBD describes broadly similar aquatic macroinvertebrate communities consistent with those reported from other regions of Alaska is incorrect, because they document taxa that have never been documented in Alaska.

Chapter 7. Cumulative and Watershed-Scale Effects of Multiple Mines

- The document should not discuss cumulative impacts with specificity from unproven resources (e.g., Humble, Groundhog).
- There has been no exploratory drilling at Groundhog.
- The potential tailings dam location at Humble is misleading, because no mining company would place tailings on top of high-value salmon-bearing waterways such as Napatoli Creek.
- Assessment should consider the effects of infrastructure development and development of a mining district (increased impervious surfaces, legal and illegal take of fish and wildlife, litter, water use and contamination, interference with subsistence uses).
- Cumulatively there is a considerable underestimation of risks, given multiple TSFs.
- Assessment should provide, at minimum, a best and worst case range.
- Assessment should address the ways in which the nature of cumulative effects (inherent complexity and uncertainty) typically is used to avoid responsibility, delay redress, and further increases losses of fishery resources.
- Assessment states that other mines will have similar risks to Pebble, but this is unlikely since the other mines would be much smaller.
- Assumes that multiple mines will jointly use facilities, which may not be valid.
- Box 7-1 is not entirely accurate and should be revised to reflect the full complexity of the Fraser River sockeye run decline.
- Expand discussion of Fraser River as highly developed system that supports robust fisheries, and stress that because Bristol Bay will never be developed to the same extent, we can ensure that Bristol Bay can be developed sustainably.
- Assumption that other large scale mines would look the same as the hypothetical scenario and have similar impacts is flawed, due to differences in site-specific conditions resulting in different site designs.

Chapter 8. Integrated Risk Characterization

- Assessment should include statements about general quality of mine waste leachate, based on EBD leachate tests.
- Lack of fish population modeling limits what assessment can really say about how any mine or mines might affect fisheries.
- Assessment should not over-simplify the system or analyses just to make it easier to understand or easier to complete. It should address more clearly that plan is to superimpose a complex facility and its operations on multiple, complex and poorly understood fish populations.
- Assessment provides a starting point, for beginning to analyze the full suite of potential impacts (considered and not considered) will interact in perpetuity.
- Potential habitat and water quality effects displayed in the conceptual diagrams and outlined in the risk assessment would be long-term continuous impacts, not independent data points.

- Assessment fails to consider socio-economic impacts to local communities, such as increased inflation, increased demand in services, increased social problems.
- Assessment mostly fails to draw connection between potential environmental impacts from large-scale mine development and important socio-economic impacts to local communities.
- Assessment underestimates impacts to wildlife
  - Should emphasize how loss of salmon will impact wildlife as food and nutrient source.
  - Should consider how transportation corridor will impact wildlife movement.
- Assessment should stress the certainty with which local residents would be culturally impacted if fish are impacted.
- Assessment should explain that all of the described effects would be mitigated.
- The streams and wetlands on the site are insignificant due to low productivity.
- Reconsider assertion that failure of one dam would relieve pressure on others. [NOTE: In Assessment, statement refers to multiple dams on a given TSF during a single event.]
  - Consider that "patched" dam would likely have less structural integrity than original and have lower elevation (i.e., that of remaining tailings).
  - Unclear how to quantify any "pressure relief" in failure statistics.

Appendix A. Fishery Resources of the Bristol Bay Region

- This information should not be used because the data are not publicly available or relevant.

Appendix B. Characterization of Selected Non-Salmon Fishes Harvested in the Fresh Waters of Bristol Bay

- This information should not be used because the data are not publicly available or relevant.
- Provide data used to identify/assess "key" fish habitat conditions (e.g., elevation, slope, groundwater).

Appendix C. Wildlife Resources of the Nushagak and Kvichak River Watersheds

- Underestimates impacts to wildlife:
  - Should emphasize how loss of salmon will impact wildlife as food and nutrient source.
  - Should consider how transportation corridor will impact wildlife movement.
- Provide data used to characterize wildlife habitat and distribution

Appendix D. Ecological Knowledge and Cultures of the Nushagak and Kvichak Watersheds, Alaska

- Commercial fishing no longer provides enough money to supplement a subsistence way of life, and additional employment is needed.
- Population is not stable; the Lake and Peninsula Borough has lost over 18% of its population since the 2000 census, and schools have been lost in Ivanof Bay and Pedro Bay due to low enrollment.
- Does not address a discussion of extremely sophisticated "ethnohydrology" of Dena'ina and other Northern Athabascan languages.
- Should emphasize disparity between locally reported ethnographic research materials, since the Pebble deposit is at the Yupik-Dena'ina interface (source materials for Dena'ina are vastly superior to those for the Yupik).
- Fails to consider socio-economic impacts to local communities, such as increased inflation, increased demand in services, increased social problems

- Could elaborate on relationship between subsistence and economics (e.g., money to purchase technology and supplies, money to replace subsistence harvests).
- Fails to consider harvest amount and composition of community harvest over time, to illustrate the potential seriousness of variation in the amount of or access to other subsistence resources.
- Importance of subsistence in social relations should be discussed further.
- Tanalian Inc. (Port Alsworth) is not a federally recognized tribe; the assessment should not treat it as such.

Appendix E. Bristol Bay Wild Salmon Baseline Levels of Economic Activity and Values

- Includes author-selected quotes by anti-mining residents that introduce bias into the report.
- Assessment did not quantify impacts to Native cultures, and should impacts beyond risks posed by potential declines in fish and wildlife.
  - Assess what will be left of these cultures after the "boom-bust" cycles associated with a mining based market economy, based on what has occurred in other areas.
- Original economic research should be conducted if economics will guide decision-making.
- Make material clearer for a lay person or public policy-maker.
- Appendix does not meet requirements of using accurate and professionally-defensible data, based on generally accepted and clearly articulated research and modeling techniques.

Appendix F. Biological Characterization: Bristol Bay Marine Estuarine Processes, Fish and Marine Mammal Assemblages

- Should be expanded to include importance of Bristol Bay as rearing habitat.

Appendix H. Geologic and Environmental Characteristics of Porphyry Copper Deposits

- The characterization of ABA results in Appendix H should be reevaluated to consider that neutralization potential may be overestimated.
- Statements that Tertiary rocks have no acid generation potential or no pyrite are not supported by the available data.
- Figures 7 and 8 are described as portraying the range of potential compositions of Pre-Tertiary and Tertiary waste rock seepage and tailings water, but they use average concentrations.
- Address fact that block caving would fracture overlying strata, allowing water and oxygen infiltration into mine. After closure, such infiltration could lead to down-gradient contamination.
- Presence of pyrite in Tertiary rocks means they would not be "lacking [in] sulfide minerals" and would require assessment for and treatment as potentially acid-generating material.
- Since zinc not present in economically recoverable quantities, it would remain in tailings and waste rock, potentially accessible to leaching with residual copper, with which it is synergistic as an ecological stressor.

Appendix I: Conventional Water Quality Mitigation Practices

- Section 1 Waste Rock
  - More recent evaluation of acid generating potential than cited is more conservative (i.e., potential exists between NP:AP ratio 1 and 2, instead of 4).

- Concerned that does not address continuing problems with acid rock drainage, even with new mines.
- Section 1.1.1 Operational Phase
  - Primary purpose of waste rock pile cover is to minimize infiltration, not to provide erosion protection or restore site.
  - Sub-economic ore can be the most problematic waste and is often not processed.
- Section 2.1.1 Tailings - Operational Phase
  - Zinc and lead typically are not mined from porphyry deposits; would be more correct to reference molybdenum, instead.
  - Meeting a limit on cyanide concentrations in TSFs and other open water facilities can be significant consideration not only in gold operations, but also when it is part of pyrite suppression.
- Section 2.2 Accidents and Failures
  - Use of unstable (when saturated) tailings for upstream dam construction is a greater threat than use of coarse tailings material.
- Section 10 Compensatory Mitigation
  - Compensatory mitigation in Bristol Bay will probably center on whether it is possible to restore salmon habitat and/or enhance fisheries through hatcheries, stream improvements, etc.
- Zinc and lead porphyry deposits do not exist.

APPENDIX B: PEER REVIEWER BIOSKETCHES

External Peer Review Meeting for *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*

Dena'ina Civic and Convention Center
Tikahtnu (Cook Inlet) Ballroom, Sections C-F
600 West Seventh Avenue
Anchorage, AK 99501

August 7-8, 2012

LIST OF PEER REVIEWERS

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BIOGRAPHICAL SKETCHES OF PEER REVIEWERS

David Atkins, M.S.
Watershed Environmental, LLC

Mr. Atkins is currently Principal Hydrologist and owner of Watershed Environmental, LLC. He works as a consultant for public and private sector clients on issues related to extractive industries and also serves as Technical Advisor to the World Bank Group's independent recourse and compliance mechanism for private sector projects (the Office of the Compliance Advisor/Ombudsman or CAO). Mr. Atkins received his Master's degrees in both Physics (1988) and Water Resources and Engineering (1994) from the University of Colorado at Boulder. He is an expert in mine hydrology, hydrogeology and geochemical assessment, with particular emphasis on acid rock drainage measurement, modeling and prediction. Mr. Atkins has extensive consulting and applied research experience with the technical aspects of mine water management (field studies, data analysis and modeling), as well as the social issues related to project development and operation (stakeholder engagement, participatory processes and conflict resolution). Mr. Atkins has conducted technical studies at various mine sites in the United States, Peru, Ecuador, Chile, Bolivia, Panamá, Guatemala, the Dominican Republic and Ghana. He has also published papers on mine impacts and acid rock drainage in journals and conference proceedings and has been an invited presenter at conferences around the world focused on evaluating impacts from development in the extractive industries.

Steve Buckley, M.S., CPG
WHPacific

Mr. Buckley is a Geologist at WHPacific in Anchorage, Alaska. Prior to joining WHPacific, he founded Watershed Consulting, LLC (1994-2009). Mr. Buckley received his B.A. (1985) and M.S. (1988) in Geology from the University of Montana at Missoula and is a Certified Professional Geologist in the state of Alaska. He has over 25 years of experience in earth science, specializing in fluvial sedimentology, geomorphology, hydrology and economic geology. Mr. Buckley applies fluvial geomorphic and hydrologic concepts to watershed analysis and stream stability, as well as to field problems in environmental geology, seismic hazards, landslide prone evaluations, and stream reconstruction. Mr. Buckley also has extensive experience working on various phases of mineral exploration projects, including reconnaissance mapping, geophysical and geochemical surveys, reverse circulation drilling, and resource calculations. He has worked throughout western North America, Alaska, Mexico, Bolivia, Chile, China, and Mongolia. Mr. Buckley's professional memberships include the American Institute Professional Geologists and Geologic Society of America.

Courtney Carothers, Ph.D.
University of Alaska Fairbanks

Dr. Carothers is an Assistant Professor in the School of Fisheries and Ocean Sciences at University of Alaska Fairbanks. Dr. Carothers received her Master's degree (2004) and Ph.D. (2008) in Anthropology from the University of Washington. Her research focuses on understanding social, cultural, and economic diversity in fishing communities. Dr. Carothers' research interest is fishery systems, subsistence, political ecology, socio-ecological change, and Alaska Native cultures. Dr. Carothers has published numerous papers, manuscripts, book reviews, and proceedings. She has also been a manuscript referee for nine journals, including *American Anthropologist*, *Ecology and Society*, and *Journal of Political Ecology*. Dr. Carothers' professional memberships include the Alaska Anthropological Association, American Anthropological Association, Society for Applied Anthropology, American Fisheries Society, and the International Arctic Social Sciences Association. She has received awards and fellowships from the National Science Foundation, Morris K. Udall Scholarship and Excellence in National Environmental Policy Foundation, American Fisheries Society, and Alaska EPSCoR Program.

Dennis D. Dauble, Ph.D.
Washington State University

Dr. Dauble is an Adjunct Professor at Washington State University, Tri-City branch campus in Richland, where he has been a member of the faculty since 1990. He previously worked at Pacific Northwest National Laboratory (PNNL) from 1973 to 2009. While at PNNL, he held several research and management positions, including Director of the Natural Resources Division, Environmental Technology Division (2000-2007). Dr. Dauble received his Ph.D. in Fisheries from Oregon State University in 1988 and holds a Master's degree in Biology (1978) from Washington State University. His professional expertise includes life history and ecology of resident and anadromous fishes, salmon passage, impacts of hydropower projects, and ecotoxicology. Dr. Dauble has published more than 60 peer-reviewed journal and symposium articles, 50 client reports, and made over 120 presentations at scientific symposia, educational workshops, and public forums. He is a Fellow of the American Institute of Fisheries Research Biologists and a member of the American Fisheries Society. He has served as scientific advisor to CALFED and the Delta Science Program in California, as well as the Hanford Reach Fall Chinook Productivity Group for Grant County PUD in Washington.

Gordon H. Reeves, Ph.D.
USDA Pacific Northwest Research Station

Dr. Reeves is currently a Research Fish Biologist with the Aquatic and Land Interaction Program of the United States Department of Agriculture (USDA), Pacific Northwest Research Station. Dr. Reeves is also courtesy Assistant Professor at Oregon State University and Humboldt State University. He received his Ph.D. in Fisheries Science in 1985 from the Oregon State University and holds a Master's degree in Fisheries Science (1978) from Humboldt State University. Dr. Reeves' research focuses on the impact of land-management practices on juvenile andadromous salmon and trout and their freshwater habitats; dynamics of aquatic ecosystems and the role of disturbances in creating and maintaining fish habitats in the Pacific Northwest and Alaska; and the development of monitoring plans. Dr. Reeves has published more than 75 publications and served as a member of the Technical Recovery Team (2003-2007) and Biological Review Team (2009-2010) for the Oregon Coast Coho Salmon Evolutionarily Significant Unit (ESU). He was also co-leader of the Aquatic Group (1993) for the Forest Ecosystem Management and Assessment Team. In 2008, he received the Alaska Region Regional Forester Excellence in Science and Technology Award from the USDA Forest Service.

Charles W. Slaughter, Ph.D.
University of Idaho

Dr. Slaughter is currently Adjunct Professor of Natural Resources and Engineering with the Center for Eco-Hydraulics Research at the University of Idaho, Boise. He was previously with Cold Regions Research and Engineering Laboratory (CRREL) ten years, then with USDA from 1976 to 2000. While at USDA, he held several research positions, including Principal Watershed Scientist (1976-1994) at the Institute of Northern Forestry, Pacific Northwest Forest & Range Experiment Station (and concurrently was Program Manager (1990-1992) for the Ecosystem Processes Research Program), and Research Leader (1994-2000) at the ARS Northwest Watershed Research Center. He also served as Acting Director of the Institute of Water Resources at the University of Alaska (1976-1977). Dr. Slaughter received his Ph.D. in Watershed Management in 1968 from Colorado State University. He has conducted and led interdisciplinary watershed and natural resource ecosystem research for more than 30 years. Dr Slaughter has authored or co-authored over 100 technical publications, and has delivered over 150 invited and offered presentations in the U.S. and abroad. He has served as proposal and/or manuscript reviewer for the National Science Foundation, Arctic and Alpine Research, Journal of Water Resources Association, Center for Field Research, Tahoe Science Consortium, Natural Resources Conservation Service, Environmental Protection Agency, and International Permafrost Association. A past Fulbright Senior Research Fellow, Dr. Slaughter's professional affiliations include American Water Resources Association, Society of American Foresters, American Geophysical Union, Arctic Institute of North America, Interagency Hydrology Committee for Alaska, Idaho Technical Committee on Hydrology, and others.

John D. Stednick, Ph.D.
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Dr. Stednick is currently a Professor and Program Leader of the Watershed Science Program in the Department of Forest and Rangeland Stewardship at Colorado State University. He received his Ph.D. in Forest Resources in 1979 from the University of Washington. Dr. Stednick's research interest is in land use and water quality, forest hydrology, water quality hydrology, natural disturbance water quality, cumulative effects, soil chemistry, biogeochemistry, water chemistry, hydrometry, watershed management, risk assessment, watershed analysis, and environmental impact assessment. Dr. Stednick has published over 250 papers, abstracts, and posters in the areas of land use and water quality. His professional affiliations include the American Geophysical Union, American Water Resources Association, and Society of American Foresters.

Roy A. Stein, Ph.D. (Chair)
The Ohio State University

Dr. Roy Stein is currently Professor Emeritus at The Ohio State University in Columbus, Ohio. He received his Ph.D. in 1975 from the University of Wisconsin and holds a Master's degree from Oregon State University. Dr. Stein has had a distinguished career in fisheries and aquatic ecology, making substantial contributions to policy-relevant science on the Great Lakes and on small inland lakes and rivers throughout the country. Dr. Stein has published over 110 peer-reviewed publications on subjects including limnology, food web ecology, fish population dynamics, and fishery management. He has served on many notable advisory committees, including being appointed by President Bill Clinton as Commissioner to the Great Lakes Fishery Commission from 1998-2004. Dr. Stein is an active member of the Ecological Society of America and the American Fisheries Society, serving on a wide variety of committees for both of these organizations. Dr. Stein has been the recipient of a variety of professional awards in fisheries science including the American Fisheries Society Award of Excellence in 2010, the Silver Eagle Award from the United States Fish and Wildlife Service in 2007, and recognized as a Fellow of the American Association for the Advancement of Sciences in 1995.

William A. Stubblefield, Ph.D.
Oregon State University

Dr. Stubblefield is currently a Senior Research Professor in the Department of Molecular and Environmental Toxicology at Oregon State University. Dr. Stubblefield received his Ph.D. in Aquatic Toxicology in 1987 from the University of Wyoming. He has more than 25 years of experience in environmental toxicology, human and environmental risk assessment, and aquatic and wildlife toxicology studies. His current research examines methods/models that can be used to predict the toxicity of metals, hydrocarbons, and mixtures to aquatic and terrestrial organisms. Dr. Stubblefield has authored more than 50 peer-reviewed publications and technical presentations in the areas of aquatic and wildlife toxicology and risk assessment. Dr. Stubblefield is an active member of the Society of Environmental Toxicology and Chemistry (SETAC), where he served as President of the Society. He has also served two terms as a member of the SETAC's Board of Directors, is currently chairman of the SETAC's Metals Advisory Group, serves on the Society's Publication Advisory Committee, and serves as a reviewer for the Society's journal, *Environmental Toxicology and Chemistry*. He has been an invited participant at a number of national and international scientific and regulatory conferences, served on peer-review panels for the Environmental Protection Agency and National Institute of Environmental Health, and frequently acts as a technical reviewer for a number of scientific publications.

Dirk J.A. van Zyl, Ph.D., P.E.
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Dr. van Zyl is currently Professor and Chair of Mining and the Environment at the Norman B. Keevil Institute of Mining Engineering, University of British Columbia. He also served as the Director of the Mining Life-Cycle Center at the Mackay School of Mines, University of Nevada, Reno. Dr. van Zyl received his Master's degree (1976) and Ph.D. (1979) in Civil Engineering from Purdue University. Dr. van Zyl has more than 35 years of experience in research, teaching, and consulting in tailings and mined earth structures. He has been involved with many mining projects that have covered the entire mining life cycle, from exploration to closure and post closure in a large range of climatic and geographic environments around the world. He is also an internationally recognized authority on sustainable mining practices. Dr. van Zyl has authored more than 100 technical papers as well as book chapters on mine waste disposal and management. His professional affiliations include the American Society of Civil Engineers and the Society of Mining Metallurgy, and Exploration. Dr. van Zyl is recipient of the 2005 Sustainable Development Award from the U. S. Bureau of Land Management, and has received multiple Citations and Awards from the Society for Mining, Metallurgy and Exploration.

Phyllis K. Weber Scannell, Ph.D.
Scannell Scientific Services

Dr. Weber Scannell is an environmental consultant and owns her own consulting company, Scannell Scientific Services. She previously worked as a Senior Biologist for the Alaska Department of Fish and Game (ADF&G) before retiring in 2003. Dr. Weber Scannell was also an Associate Professor at the University of Alaska Fairbanks and taught various courses on lakes, rivers and streams and quantitative fish biology. Dr. Weber Scannell received her Ph.D. in 1981 from the College of Forest Resources and School of Fisheries at the University of Washington. Dr. Weber Scannell has a broad understanding of Alaska fisheries, water quality, aquatic toxicology, and permitting. She has published over 15 papers and technical reports pertaining to biomonitoring and water quality standards. Dr. Weber Scannell's professional affiliations include the American Fisheries Society, American Institute of Fisheries Research Biologists, North American Lake Management Society, and Society of Environmental Toxicology and Chemistry.

Paul Whitney, Ph.D.
Independent Consultant

Dr. Whitney is a semi-retired consultant in Portland, Oregon. He previously worked as an Ecologist for Beak Consultants Inc., where he served as President and Chair Board for before retiring in 2010. Dr. Whitney received his Ph.D. in Ecology/Physiology in 1972 from the University of Alaska Fairbanks and holds a Master's degree in Zoology (1967) from Indiana University. He has extensive experience in wildlife ecology, fish and wildlife interaction, planning and design of wetlands and uplands to enhance wildlife habitat and water quality, wildlife impact assessment, and ecological risk assessment. As a consultant, he specialized in landscape-based Alternative Analyses and Cumulative Impact Assessments for Clean Water Act and National Environmental Policy Act efforts. He was also a principal investigator for the

International Biological Program in arctic and subarctic Alaska. His publications appear in journals such as *Science*, *Ecology*, *Ecological Monographs*, *Canadian Journal of Zoology* and *Acta Theriologica*. Dr. Whitney has participated in many scientific advisory committees, including the Oregon Department of Environmental Quality Ecological Risk Assessment Methodology, Portland METRO Regional Significant Natural Resource Technical Advisory Committee (TAC), City of Portland River Renaissance Framework TAC, and Northwest Power Planning and Conservation Council Multi-species Framework Science Advisory Committee. He was also a member of the Ecological Society of America and the Oregon Chapter of the Wildlife Society.

APPENDIX C: MEETING AGENDA

External Peer Review Meeting for *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*

Dena'ina Civic and Convention Center
Tikahtnu (Cook Inlet) Ballroom, Sections C-F
600 West Seventh Avenue
Anchorage, AK 99501

August 7, 2012

AGENDA – Day 1

7:30 AM	**Meeting Sign-In Begins**
8:30 AM	**Welcome, Goals of Meeting, and Introductions** David Bottimore, Versar, Inc.
8:45 AM	**Welcome by EPA** Dennis McLerran, EPA Region 10
8:55 AM	**Facilitator's Introduction of Observer Comment Session** Robert Wheeler, Triangle Associates, Inc.
9:10 AM	**Observer Comment Session**
10:15 AM	***Break****
10:30 AM	**Observer Comment Session (continued)**
12:00 PM	***Lunch (on your own)****
1:00 PM	**Observer Comment Session (continued)**
3:00 PM	***Break****
3:15 PM	**Observer Comment Session (continued)**
5:20 PM	**Closing Remarks** David Bottimore, Versar, Inc.
5:30 PM	**Adjourn**

External Peer Review Meeting for *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*

August 8, 2012

AGENDA – Day 2

7:30 AM	**Meeting Sign-In Begins**
8:00 AM	**Welcome, Goals of Meeting, and Introductions** David Bottimore, Versar, Inc.
8:15 AM	**Chair's Introduction and Review of Charge** Roy Stein, *Chair*
8:30 AM	**Discussion Session – General Overview Comments**
9:00 AM	***Break****
9:15 AM	**Discussion Session – Responses to Charge Questions:** Question 1: Accuracy and Completeness of Assessment Question 2: Hypothetical Mine Scenario – Realism and Magnitude Question 3: No-failure Mode of Operation and Engineering and Mitigation Question 4: Risks to Salmonid Fish – No Failure Mode of Operation
11:30 AM	***Lunch (on your own)****
12:30 PM	**Discussion Session – Response to Charge Questions:** Question 5: Failure Probabilities and Risks Question 6: Risks to Salmonid Fish - Failure of Water/Leachate Treatment Question 7: Risks to Salmonid Fish - Culvert Failures in Transportation Corridor Question 8: Risks to Salmonid Fish - Pipeline Failures Question 9: Risks to Salmonid Fish - Tailings Dam Failure
3:15 PM	***Break****
3:30 PM	**Discussion Session – Response to Charge Questions:** Question 10: Risks to Wildlife and Human Cultures Due to Risks to Fish Question 11: Cumulative Risks from Multiple Mines Question 12: Other Mitigation Measures Question 13: Uncertainties and Limitations Question 14: Other Comments Concerning the Assessment
6:00 PM	**Adjourn**

On Day 3, the peer reviewers will be meeting in a closed session to document the events and deliberations of Days 1 and 2. Day 3 will not be open to the public for observation or speaking; however, the final peer review comments on the assessment will be made available to the public.

APPENDIX D: MEETING ATTENDEE AND SPEAKER LISTS

Meeting Attendee List

External Peer Review Meeting for

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7-8, 2012

#	Last Name	First Name	Affiliation
1	Adams	Eric	Alaska Dispatch
2	Adleman	Jennifer	AK Dept. of Commerce, Community and Economic Development
3	Aicher	Rebecca	USEPA-ORD (AAAS Fellow)
4	Akelkok	Luki	Nonprofit Organization
5	Albert	David	The Nature Conservancy
6	Alkire	Matty	KTBY/KYUR
7	Allen	Doug	Northern Dynasty Minerals Ltd.
8	Andrew	Melvin	Pebble Limited Partnership
9	Andrew	Peter	None
10	Andrew	Bobby	None
11	Andrew Jr.	Greg	Levelock Village Council
12	Anelon	Martha	Bristol Bay Resident
13	Anelon Sr	Tim	Iliamna Village Council
14	Angasan	Trefon	Tribal Counsel and Represenative
15	Angasan	Brad	Wetovik
16	Angasan	Gwen	Subsistence User from Kokhanok Tribe
17	Apokedak	Raymond	Vice President, Levelock Village Council
18	Ashton	William	AK Dept. of Environmental Conservation
19	Austin	Lyle	None
20	Barnwell	Charles	AMA
21	Bauman	Margaret	The Fishermen's News, Seattle
22	Beale	Geoff	Pebble Limited Partnership
23	Beischer	Gregory	Millrock Resources Inc.
24	Berna	Robert	None
25	Blair	Melissa	National Parks Conservation Association
26	Blair	Greg	ICF
27	Blas	Leo	None
28	Boraas	Alan	Kenai Peninsula College
29	Borell	Steven	None
30	Bosma	Julia	None
31	Bottimore	David	Versar, Inc.
32	Bradner	Tim	AK Journal of Comm.
33	Brewer	Marty	None
34	Brna	Phil	USFWS
35	Brown	Jim	Alaska Pacific University
36	Brown	Mel	Bristol Bay Native Corporation
37	Brune	Jason	Anglo American
38	Bryan	Todd	The Keystone Center

Meeting Attendee List

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7-8, 2012

#	Last Name	First Name	Affiliation
39	Burger	Paul	National Park Service
40	Burger	Kathryn	None
41	Burke	Jill	Alaska Dispatch
42	Cage	Evelyn	None
43	Calcote	Delice	Alaska Inter-Tribal Council
44	Campbell	Melissa	Bristol Bay Native Corporation/Bristol Industries
45	Carrier	Rejean	Pebble Limited Partnership
46	Chambers	David	Center for Science in Public Participation
47	Chapman	John	None
48	Cheyette	Daniel	Bristol Bay Native Corporation
49	Chukwak	Sergie	None
50	Chythlook	Joseph	Bristol Bay Native Corporation
51	Clark	Sharon	Clarks Point Village Council
52	Cobb	Charles	Alaska DNR Dam Safety Unit
53	Collier	Thomas	None
54	Colon	Betzy	Versar, Inc.
55	Cox	Brian	Yankton Sioux
56	Crafford	Tom	AK Dept. of Natural Resources
57	Craig	Hanna	Media Action
58	Crockett	Deantha	Alaska Miners Association
59	Cronin	Matthew	University of Alaska Fairbanks
60	Curtis	Jacob	KTVA CBS
61	Dahl	Wilben	None
62	Daigneault	Michael	Alaska Dept. of Fish and Game, Division of Habitat
63	Dean	Heather	USEPA-Region 10
64	Demer	Lisa	Anchorage Daily News
65	Donn	Calliandra	Commercial Fishing
66	Dunham	Willard	None
67	Eaton	Daysha	APRN
68	Ebersole	Joe	USEPA-ORD
69	Ekstrom	Brittany	Versar, Inc.
70	England	Charles	None
71	Fagnani	Matthew	None
72	Ferguson	Anna May	Traditional Council of Togiak
73	Fiorucci	Dan	KTUU TV
74	Fleagle	Donne	Alaska Peninsula Corporation, Wetaviq LTD
75	Foley	Jeffrey	Resource Development Council
76	Fordham	Tami	USEPA-Region 10

Meeting Attendee List

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7-8, 2012

#	Last Name	First Name	Affiliation
77	Fortier	Sam	Alaska Peninsula Corporation
78	Frithsen	Jeffrey	USEPA
79	Galbraith	Les	Knight Piesold
80	Gamache	Jean	National Park Service, Alaska Region
81	Gestring	Bonnie	Earthworks
82	Giessel	Cathy	State of Alaska
83	Glooschenko	Valanne	Member, Society of Wetland Scientists
84	Godsey	Cindi	USEPA-Region 10
85	Gosuk	Steven	Pebble Limited Partnership
86	Gottschalk	Archie	A. N. Gottschalk & Associates
87	Grey	Howard	Foundex Pacific, Inc.
88	Gridley	Norman	Anglo American
89	Grismala	Ralph	ICF
90	Hagerstein	Randy	None
91	Haile	Jeremy	Knight Piesold
92	Hardesty	Todd	Bradley Reid
93	Hastings	Margie	New Stuyahok Traditional Council
94	Hayes	Jeremy	None
95	Heatwole	Mike	Pebble Limited Partnership
96	Hébert	Karen	Yale University
97	Heese	Ruth	State of Alaska
98	Henry	Paul	Anglo American
99	Henry	Amanda	MWH Global
100	Hill	Erik	Anchorage Daily News
101	Hillstrand	Nancy	Pioneer Alaskan Fisheries Inc.
102	Horrell	William	None
103	Hostman	James	None
104	Hough	Palmer	USEPA-OW
105	Hughes	Robert	Department of Fisheries & Wildlife, Oregon State University
106	Hulse	Elaine	None
107	Hurley	Jimmy	None
108	Iani	John	Perkins-Coie, LLP
109	Jenkins	Roger	AMAPAC
110	Jesperson	Michael	None
111	Johnson	Charlie	Portage Creek Village Council
112	Johnson	Mary Ann	Portage Creek Village Council
113	Johnson	Michael	South Naknek
114	Johnson-Young	Karen	None

Meeting Attendee List

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7-8, 2012

#	Last Name	First Name	Affiliation
115	Kader	Hanady	USEPA-Region 10
116	Kari	James	Alaska Native Language Center, UAF
117	Kavanaugh	Michael	None
118	Kiekow	Taryn	NRDC
119	King	Richard	Ekwok Village Council
120	King	Lorraine	Ekwok Village Council
121	Koller	Richard	None
122	Kruse	Seth	Bristol Bay Native Corporation
123	Larson	Dorothy	Bristol Bay Native Corporation
124	Loeffler	Robert	Consultant to Lake and Peninsula Borough
125	Luetters	Susan	Bristol Bay Native Association
126	Lund	Gary	None
127	Maest	Ann	Stratus Consulting, Inc.
128	Magee	Sean	None
129	Mauger	Sue	Cook Inletkeeper
130	Maynard	Myrna	None
131	Maynard	Kenneth	None
132	Mazurek	Megan	KTBY/KYUR
133	McCarr	Sarah	Pebble Limited Partnership
134	McCreadie	Hugh	Piteau Associates
135	McDaniel	Matthew	Independant
136	McLerran	Dennis	USEPA-Region 10
137	McPherson	Kate	KTVA CBS
138	Mendenhall	Vivian	None
139	Metton	Sarah	Franklin and Ash LLC
140	Mikkelsen	Richard	None
141	Mohr	Benjamin	Pebble Limited Partnership
142	Nakanishi	Allan	AK Dept. of Environmental Conservation
143	Nelson	Russell	None
144	Nelson	Herman	New Koliganek Village Council
145	Nielsen	Donald	South Naknek Village Council
146	Nielsen	Shirley	Tribal representative to the BB Elders Forum from Kokhanok
147	Nielsen	Jens	Kokhanok Village Council
148	North	Phil	USEPA-Region 10
149	O'Neal	Sarah	Fisheries Research & Consulting
150	Oxford	Mariah	Bristol Bay Native Corporation - Pebble Watch Program
151	Parker	Geoffrey	Tribes
152	Parkin	Richard	USEPA-Region 10

Meeting Attendee List
External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska
August 7-8, 2012

#	Last Name	First Name	Affiliation
153	Pastos	Nikos	Center for Water Advocacy
154	Paul	Kendall	Cold Storage - State Senate Candidate
155	Petro	Rachael	Alaska State Chamber of Commerce
156	Phillips	Nellie	Bristol Bay Native Corporation
157	Pratt	Steve	Consumer Energy Alliance Alaska
158	Reimers	Lisa	Tribal Member
159	Richards	Paul	Alaska Miners Association
160	Richardson	Robin	Copper River Seafoods
161	Rieser	Michael	None
162	Riley	Karie	Versar, Inc.
163	Riley	William	Bristol Bay Native Corporation
164	Robinette	Jennifer	Ekuk Village Council
165	Rockwell	Ted	None
166	Ryan	Kristin	EPA
167	Samuelsen	Robin	Bristol Bay Economic Development Corporation
168	Sandberg	Kate	None
169	Sargent	Christina	Versar, Inc.
170	Sarraino	Stephanie	Versar, Inc.
171	Satre	Michael	Council of Alaska Producers
172	Sayers-Fay	Andrew	Department of Environmental Conservation
173	Schindler	Daniel	University of Washington
174	Schmidt	Herman	None
175	Schofield	Kate	USEPA-ORD
176	Schwartz	Richard	Crowell & Moring LLP
177	Seville	Steve	ICF
178	Shively	John	Pebble Limited Partnership
179	Simons	Daniel	None
180	Slaughter	Mary	None
181	Smith	Carolyn	Northern Dynasty Minerals Ltd.
182	Smythe	Tom	None
183	Snyder	Samuel	Alaska Conservation Foundation
184	Soderlund	Dianne	USEPA-Region 10
185	Sohn	Tim	Outside Magazine
186	Stambaugh	Sharmon	AK Department of Natural Resources
187	Steiner-Riley	Cara	USEPA-Region 10
188	Stevenson	Kalb	Pebble Limited Partnership
189	Struble	Barbara	None
190	Sturdy	Michelle	BNNC, Bristol Engineering Services Corp.

Meeting Attendee List

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7-8, 2012

#	Last Name	First Name	Affiliation
191	Sturgeon	John	None
192	Sussman	Bob	EPA
193	Suter	Glenn	USEPA-ORD
194	Taylor	Ken	Retired
195	Tesch	Laura	None
196	Thiessen	Mark	Associated Press
197	Tilden	Thomas	Curyung Tribal Council
198	Toyukak	Moses	Village Councilmember
199	Treinen	Chip	United Fishermen of Alaska
200	Troll	Tim	Bristol Bay Heritage Land Trust
201	Tyler	Jamen	Native American Rights Fund
202	Ulmer	Brent	None
203	Van Tuyn	Peter	Bessenyey & Van Tuyn, L.L.C.
204	Varner	Andy	Southwest Alaska Municipal Conference
205	Waldrop	Bob	Bristol Bay Regional Seafood Development Association
206	Walsh	Bob	Senator Murkowski's Office
207	Ward	Thomas	None
208	Wassillie	Raymond	Newhalen Tribal Council
209	Weglinski	Gene	Tetra Tech
210	Wheeler	Robert	Triangle Associates
211	Wigington	Jim	USEPA-ORD
212	Williams	Kimberly	Nonprofit Organization
213	Williams	Nelli	Trout Unlimited
214	Williams	Abe	Nuna Resources
215	Wilson III	Verner	World Wildlife Fund
216	Winkley	Barbara	Interested Citizen
217	Woody	Carol Ann	Fisheries Research & consulting (Owner)
218	Wright	Leslie	None
219	Zamzow	Kendra	Center for Science in Public Participation
220	Zencey	Kyle	None

List of Public Speakers

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7, 2012

Assigned Speaker #*	Name	Affiliation	Category
1	John Shively	Pebble Limited Partnership	SOM
2	Laura Tesch	Pebble Limited Partnership	SOM
3	Richard Schwartz	Crowell & Moring LLP	SOM
4	Melvin Andrew	Pebble Limited Partnership	SOM
5	Trefon Angasan	Tribal Counsel and Representative	SOM
6	Kendra Zamzow	Center for Science in Public Participation	SOM
7	John Sturgeon	None	SOM
8	Mike Heatwole	Pebble Limited Partnership	SOM
9	Paul Henry	Anglo American	SOM
10	Shirley Nielsen	Tribal Rep. to the BB Elders Forum from Kokhanok	SOM
11	Steven Borell	None	SOM
13	Jeffrey Foley	Resource Development Council	SOM
14	Howard Grey	Foundex Pacific, Inc.	SOM
15	Jens Nielsen	Kokhanok Village Council	SOM
16	Michael Satre	Council of Alaska Producers	SOM
17	Michael Kavanaugh	Consultant to Northern Dynasty Minerals Ltd.	PFP
18	David Chambers	Center for Science in Public Participation	PFP
19	Les Galbraith	Knight Piesold	PFP
20	Jeremy Haile	Knight Piesold	PFP
21	Ann Maest	Stratus Consulting, Inc	PFP
22	Samuel Snyder	Alaska Conservation Foundation	PFP
24	Bonnie Gestring	Earthworks	PFP
25	Norman Gridley	Anglo American	PFP
26	William Riley	Bristol Bay Native Corporation	PFP
28	Hugh McCreadie	Piteau Associates	HYD
29	Geoff Beale	Pebble Limited Partnership	HYD
30	Archie Gottschalk	A. N. Gottschalk & Associates	HYD
31	David Albert	The Nature Conservancy	HYD
32	Sue Mauger	Cook Inletkeeper	HYD
35	Martha Anelon	Bristol Bay Resident	EAN
36	Donne Fleagle	Alaska Peninsula Corporation, Wetaviq LTD	EAN
37	Geoffrey Parker	Counsel to Tribes and Others	EAN
38	Kimberly Williams	Nunamta Aulukestai	EAN
39	Greg Andrew Jr.	Levelock Village Council	EAN
40	Russell Nelson	None	EAN
41	Sharon Clark	Clarks Point Village Council	EAN
42	Anna May Ferguson	Traditional Council of Togiak	EAN

***SOM**: Mine Scenarios & Operational Modes, **PFP**: Potential Failures and Probabilities, **HYD**: Hydrology, **EAN**: Potential Effects on Alaska Native Culture, **PEF**: Potential Effects on Fish, **PEW**: Potential Effects on Wildlife, **OTH**: Other*

List of Public Speakers

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7, 2012

Assigned Speaker #*	Name	Affiliation	Category
44	Sarah McCarr	Pebble Limited Partnership	EAN
45	Herman Nelson	New Koliganek Village Council	EAN
46	Steve Pratt	Consumer Energy Alliance Alaska	EAN
47	Thomas Tilden	Curyung Tribal Council	EAN
48	Abe Williams	Nuna Resources	EAN
49	Charlie J. Johnson	Portage Creek Village Council	EAN
50	Delice Calcote	Alaska Inter-Tribal Council	EAN
51	Margie Hastings	New Stuyahok Traditional Council	EAN
52	Nancy Hillstrand	Pioneer Alaskan Fisheries Inc.	PEF
53	Luki Akelkok	Nunamta Aulukestai	PEF
54	Sarah O'Neal	Fisheries Research & Consulting	PEF
55	Nikos Pastos	Center for Water Advocacy	PEF
56	John Iani	Perkins-Coie, LLP	PEF
57	Michelle Sturdy	Bristol Engineering Services Corp.	PEF
58	Tim Troll	Bristol Bay Heritage Land Trust	PEF
59	Nelli Williams	Trout Unlimited	PEF
62	Calliandra Donn	Commercial Fishing	PEF
63	Valanne Glooschenko	Member, Society of Wetland Scientists	PEF
64	Robin Richardson	Copper River Seafoods	PEF
65	Carol Ann Woody	Fisheries Research & Consulting	PEF
67	Taryn Kiekow	Natural Resources Defense Council	PEW
68	Seth Kruse	Bristol Bay Native Corporation	PEW
69	Vivian Mendenhall	None	PEW
70	Matthew Cronin	University of Alaska Fairbanks	PEW
72	Verner Wilson III	World Wildlife Fund	PEW
73	Thomas Collier	Counsel to Northern Dynasty Minerals Ltd.	OTH
74	Sean Magee	Northern Dynasty Minerals	OTH
76	Richard King	Ekwok Village Council	OTH
77	Rachael Petro	Alaska State Chamber of Commerce	OTH
78	Lisa Reimers	Tribal Member	OTH
79	Deantha Crocket	Alaska Miners Association	OTH
80	Tom Crafford	Alaska Department of Natural Resources	OTH
81	Jimmy Hurley	None	OTH
82	Michael Jesperson	None	OTH
83	Kalb Stevenson	Various	OTH
87	William Horrell	None	OTH
92	John Chapman	None	OTH

SOM: *Mine Scenarios & Operational Modes,* ***PFP***: *Potential Failures and Probabilities,* ***HYD***: *Hydrology,* ***EAN***: *Potential Effects on Alaska Native Culture,* ***PEF***: *Potential Effects on Fish,* ***PEW***: *Potential Effects on Wildlife,* ***OTH***: *Other*

List of Public Speakers

External Peer Review Meeting for
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

August 7, 2012

Assigned Speaker #*	Name	Affiliation	Category
94	Matthew Fagnani	None	OTH
95	Susan Luetters	Bristol Bay Native Association	OTH
97	Gregory Beischer	Millrock Resources Inc.	OTH
98	Joseph Chythlook	Bristol Bay Native Corporation	OTH
99	Robert M. Hughes	Oregon State University	OTH
100	Robin Samuelsen	Bristol Bay Economic Development Corporation	OTH
101	Daniel Schindler	University of Washington	OTH
102	Tim Anelon Sr.	Iliamna Village Council	OTH
103	Brad Angasan	Wetaviq	OTH
104	Gwen Angasan	Subsistence User from Kokhanok Tribe	OTH
105	Jason Brune	Anglo American	OTH
106	Sam Fortier	Alaska Peninsula Corporation	OTH
109	Donald Nielsen	South Naknek Village Council	OTH
110	Jennifer Robinette	Ekuk Village Council	OTH
111	Raymond Wassillie	Newhalen Tribal Council	OTH
112	James Kari	University of Alaska Fairbanks	OTH
114	Charles Barnwell	AMA	OTH
115	Willard E. Dunham	None	OTH
116	Steven Gosuk	Pebble Limited Partnership	OTH

**Numbers designating the order in which speakers would provide comments were assigned prior to the meeting. Speaker numbers missing from this list were assigned to individuals who registered to provide comments, but did not attend the meeting on August 7th to present their comments to the peer reviewers.*

***SOM**: Mine Scenarios & Operational Modes, **PFP**: Potential Failures and Probabilities, **HYD**: Hydrology, **EAN**: Potential Effects on Alaska Native Culture, **PEF**: Potential Effects on Fish, **PEW**: Potential Effects on Wildlife, **OTH**: Other*