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15 September 2013

Rep. Paul Broun, M.D.
Chairman, Subcommittee on Oversight
Committee on Science, Space and Technology
House of Representatives
2321 Rayburn House Office Building
Washington DC 20515-6301

Subject: Response to Questions for the Record following the August 1, 2013 Hearing on "EPA's Bristol Bay Watershed Assessment – A Factual Review of a Hypothetical Scenario"

Dear Representative Broun:

Attached to this letter are my responses to the questions submitted by you and by Congressman Maffei, and my responses to comments made by Mr. William Riley in his letter dated August 14, 2013. In addition, as it addresses one or more of the questions asked, I am also attaching Geosyntec's letter dated 22 May 2013 presenting our assessment of the 2nd Draft of the EPA's Bristol Bay Watershed Assessment.

Sincerely,

Michael Kavanaugh, PhD, PE, NAE
Senior Principal

Attachment: Responses to Questions for the Record
Geosyntec Review of 2nd Draft BBWA

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON OVERSIGHT

"EPA's Bristol Bay Watershed Assessment - A Factual Review of a Hypothetical Scenario"

RESPONSES TO QUESTIONS FOR THE RECORD

Dr. Michael Kavanaugh, Senior Principal, Geosyntec Consultants, and Member, National Academy of Engineering

Questions submitted by Chairman Paul Broun

1) *You say in your testimony that, "the BBWA exaggerates the probability of failures." Scientifically speaking, how could EPA's document be strengthened?*

- There are many ways in which the BBWA should be strengthened from an engineering analysis perspective as outlined in my written testimony and the Geosyntec reviews of the two versions of the BBWA, but one of the most important shortcomings is the reliance on an hypothetical mine scenario to assess the potential watershed impacts of the hypothetical project. The use of the Wardrop report[1] as a surrogate for an actual mine plan misrepresents the level of detail on analysis, design and mitigation that would be included in a plan required during a NEPA permitting review. The Wardrop report explicitly states its purpose as an economic assessment of three development scenarios, and while engineering calculations are needed to estimate the cost of the development, no formal design with engineering documentation is provided for the mine elements that are presented, or the mitigation measures and redundant design features that would be included in the mine plan.

- The BBWA would need to focus on more than just worst case scenarios, including partial failures of components of the mining infrastructure. In addition, a proper scientific and engineering evaluation of the risks and consequences of these various scenarios would need to be performed. This evaluation is not a simple undertaking, and in my opinion is best left to the permitting process, when the regulatory agencies can work with Pebble based on an actual project plan. The permitting process identifies the scenarios that need to be evaluated, and the probability of those scenarios occurring can be subjected to detailed review by regulatory experts to provide the bases for a credible risk analysis, and identification of design changes or mitigation measures needed to meet acceptable levels of risk. EPA has not performed a risk analysis that meets quality requirements because they have failed to assess the probability of occurrence of the failure scenarios postulated for the mine infrastructure components.

[1] Wardrop. 2011. *Preliminary Assessment of the Pebble Project, Southwest Alaska.* Prepared for Northern Dynasty Minerals Ltd., February 15, Prepared by Wardrop (A Tetra Tech Company), Vancouver, BC.

2) *Does EPA's assessment use modern engineering standards to evaluate impacts of a potential mining project on the natural resources of the Bristol Bay? If not, what standards are used and do you know why these standards would be used instead of modern day standards?*

   a. *Are you aware of any other instances when EPA or any other federal agency used antiquated standards for modern assessments?*

- I am not aware of other instances where antiquated standards have been used by EPA or other federal agencies in decision making on mine development.

- It is not entirely clear what standards were used by EPA in preparing the BBWA with respect to assessment of the probability of failure of mine infrastructure. In most cases, there were no standards referenced, or if they were, they were referenced but not applied as the basis for the failure scenarios. The most prominent example may be the use of literature supporting culvert failure rates (defined as blocking of fish passage) of 30%-58% which were often based on culverts that were not even permitted in the first place and clearly did not adhere to current design standards. The authors in the studies note that the issues observed could have been prevented with proper design, installation, and/or maintenance. A project being designed under current regulations with stringent environmental standards and regulatory oversight should be expected to be executed with much greater care such that fish passage standards are met at each crossing.

  Another example is the BBWA's reliance on outdated case histories to represent the state of engineering associated with the design, construction and operation of tailings storage facilities (TSFs). As documented elsewhere, reliance on 135 case studies of TSF failures to estimate failure probability of a future TSF is scientifically inaccurate. A modern TSF, especially on the scale of the Pebble project, would be designed, built, and operated based on best science and engineering, and in a manner that would have learned from past mistakes. In fact, all of the failure modes responsible for the 135 failure studies are well recognized and these failures have been carefully analyzed, thus providing the basis for improved design and operational plans for modern mines.

  The mining practice has continued to evolve, and Pebble must meet the challenge to demonstrate to the regulatory agencies that appropriately high standards will be used in designing, constructing, and operating the mine through its life cycle.

3) *As a member of the National Academies Report Review Committee, which oversees the quality program for all NRC reports, you have unique experience in reviewing products issued by the National Academies. Recognizing that there are different methods involved between NAS documents and EPA's watershed assessment, how does the assessment compare to the average NAS, document in the categories of stating and meeting objectives as well as scientific soundness?*

- The BBWA has relied on a peer review panel process as well as a public comment period to oversee the scientific quality of the Report. The response to the comments was organized by a contractor for EPA, Versar, and the response document prepared for the first version of the BBWA did not provide a detailed commentary on the major criticisms to the Report. While the NRC process is not public, the NRC staff provides a detailed response to all comments from each reviewer of an Academy report. This level of detail is missing in the EPA review process, with the result that it is unclear which comments were not addressed and for what reason(s). This is definitely a shortcoming of the review process applied to the BBWA.

4) *Do you believe that the composition of the peer review panel selected for EPA's watershed assessment was sufficiently diverse and knowledgeable on the subject matter? Do you have any recommendations relative to the expertise of the panel members?*

- Given that much of the focus of the BBWA is on the failures of engineered systems, it is unfortunate that there was only one engineer with mining expertise on the panel. I would recommend that several engineers be included on the peer review panel, with expertise in the various critical mining infrastructure elements being evaluated in the BBWA, given the importance of failure scenarios in assessing the potential impacts of the mine.

5) *Do you consider EPA's peer review process for both drafts of the Bristol Bay watershed assessment to be adequate and transparent? Do you have any suggestions on how EPA could have handled the peer review processes?*

- As noted in my previous response, the major shortcoming in the first phase of EPA's peer review process was the lack of transparency in response to comments for the public. While comments from the peer review panel members were discussed in some detail, it was still unclear why some critical comments were not discussed, nor responded to in the revised draft. In the second phase of peer review on the revised BBWA, documents have not yet been published by EPA to assess what responses will be forthcoming, or how the BBWA may be revised. Regarding the 2013 process, I will repeat two statements from my formal written testimony dated 29 July 2013:

> "Even though the 2013 Assessment nearly doubled in size, with major organizational changes and substantial amounts of new information, no opportunities have been provided to allow for public interaction with the external peer review panel. Neither the charge to the external peer committee in this latest round, nor procedures to respond to committee questions have been made available on USEPA's website."
>
> "In addition, following peer review of the 2012 BBWA, USEPA undertook additional external peer review of seven documents selected by the agency as relevant to mining activities in Alaska. This component of the peer review process was not done in a transparent manner, with little information provided on how or why these seven documents were chosen, how the peer reviewers were selected, and how the USEPA responded to the comments prepared by the reviewers of these seven reports. The lack of transparency on this aspect of the peer review process is disturbing since the documents were widely quoted in the 2013 BBWA. Such lack of transparency on these

highly relevant documents undermines the credibility of the final document."

6) *In its second draft, did EPA incorporate any of the concerns or recommendations submitted by Geosyntec for public comment?*

- Geosyntec prepared a review of the second draft of the BBWA. In that review letter, dated 22 May 2013, numerous examples were given of how Geosyntec's comments on the first draft were not addressed nor incorporated (see Table 1 in the attached copy of the review letter). On occasion, obvious flaws identified in the first draft were removed in the second draft. However, the second draft BBWA is a much larger document and includes a substantial amount of new content. Our initial rapid review identified significant concerns with the new content, and more concerns would likely have been provided had there been sufficient time for review.

7) *Given the uniqueness of the Bristol Bay Watershed, is it more appropriate to try to protect the area from development through a watershed assessment, or should there be a more thorough process undertaken, via the, NEPA process, to analyze all aspects of potential mining?*

- Clearly a project of this magnitude warrants a very thorough and exhaustive review process with assurances that the project being reviewed is based on an actual proposed plan, with reference to all available documentation and including mitigation plans where appropriate. The BBWA has provided some value, in that it provides insight into regulatory concerns regarding the development. However, both in its scope and in its execution, the BBWA is insufficient for informing regulatory decisions.

  That is the role of the NEPA/EIS process, which has been well tested over the years since the passage of the NEPA statute, and is a far more robust and thorough assessment of all aspects of a proposed mining project. This process is also well established in Alaska, as applied to applications for permits to construct and operate a hard rock mine. Furthermore, the NEPA/EIS process would carefully evaluate all components of an actual mine plan in the context of well-established regulations applied to all components of the mine. The NEPA/EIS process, by definition, would be far more thorough than the BBWA in analyzing the need for mitigation measures and specifying what those mitigation measures should be in order to satisfy permit requirements. In summary, the well-established NEPA/EIS process should provide a far more thorough risk analysis of the actual mining plan compared to the BWWA.

8) *Is EPA's watershed assessment scientifically robust enough to be the basis of a preemptive veto under Section 404 (c) of the Clean Water Act?*

- In my opinion, the BBWA does not meet the standard of care for a scientifically defensible ecological risk assessment or risk analysis. Our (Geosyntec Consultants, Inc) review of the BBWA indicated that there were numerous flaws in the document such that it does not present a fair and unbiased assessment of the project. Among those numerous flaws is a failure to make full use of the extensive baseline environmental data produced by the mine proponents.

9) *Please find attached a letter to the Committee from Mr. William Riley, who worked for the EPA's Region 10 Office in Seattle, Washington from 1980 to 2007. Mr. Riley's letter includes comments on portions of your testimony for the August 1, 2013 hearing. Do you have any response to his comments?*

- Thank you for the opportunity to comment on Mr. Riley's letter. My specific remarks in response to his critique of my testimony is provided after the responses to Congressman Maffei's questions.

Questions submitted by Rep. Daniel Maffei (D-NY)

Your testimony painted a rosy scenario of how new mining technologies would overcome all potential adverse impacts of hard rock mining in the Pebble prospect. You were particularly dismissive of "low probability" scenarios in the EPA assessment as simply painting an alarmist portrait. Curiously, the EPA draft assessment concludes that even without the "low probability" scenarios, the damage from the proposed mine would be significant. In any case, the Science, Space, and Technology Committee has heard many experts over the years assure us of the ability of technology to reduce risk, that nay-sayers overstate risks and that new techniques harnessed to expert knowledge render those who see risk irrelevant to an accurate assessment of a proposal. But year after year, we see how complex systems collapse through technological failure, human error or natural disaster. The worst cases often involve all three elements working in horrific concert--the Fukushima Nuclear Power Plant is the most recent example of such a failure. This leads me to ask that you provide the following information:

- I would first like to respond to the following statement:

> *"But year after year, we see how complex systems collapse through technological failure, human error or natural disaster. The worst cases often involve all three elements working in horrific concert--the Fukushima Nuclear Power Plant is the most recent example of such a failure."*

I have repeated this statement from the Congressman's opening remarks because it represents a significant misunderstanding of what engineers and scientists do, and this misunderstanding is in part a root cause of disagreements over development projects. The essence of the human condition is the development of engineered systems designed to achieve some economic goal, while not causing unacceptable impacts to human health and the environment. Since the industrial revolution, the built environment has evolved to a point where the vast majority of engineered systems operate safely and effectively over their intended life span. Most bridges do not fail, but some do. Most modern buildings withstand earthquakes if properly designed. The first production commercial jetliners suffered significant problems and three well publicized crashes occurred due to what was ultimately found to be design flaws, and yet we still fly in airplanes today.

To compare Pebble to the Challenger disaster, as EPA did in the second version of the Watershed Assessment, or to the Fukushima Nuclear disaster, is an unjustifiable distortion of the well-known engineering challenges facing the Pebble mine. The key structure that has been the focus of much attention, namely the Tailings Storage Facility (TSF) will be built based on the experiences gained from design, construction and successful operation of thousands of earthen structures that have been constructed over the past decades. This does not mean that any system is "fail safe" but it does mean that systems can and will be designed to withstand credible failure scenarios. It is important to note that no regulatory requirements demand that a system be "fail safe", only that safety factors and design elements be incorporated that are "reasonable" and reflect "reasonable" assumptions. In the case of the Pebble Mine, the permitting process is designed to assess carefully the engineering requirements for a mining project that will meet permit requirements in Alaska. That is why the mine developers deserve an opportunity to present their case to regulators in support of an actual mine plan designed to minimize system failures and have systems in place to respond quickly should certain failure modes occur.

1) *For a mine equivalent in size to EPA's mid-scale model, how many years do you believe a tailings dam would have to perform perfectly to insure no watershed damage from acid waste runoff?*

- A tailings dam for a modern mine should be designed, constructed, operated, and maintained to meet appropriate regulatory standards. These standards are established based on the best available science and engineering available at the time. Both the regulatory standards and the tools and knowledge available to the practice evolve over time. A project of this size should be held to the highest standards, both regulatory standards and construction, design, operations and maintenance standards, until it can be demonstrated that the both the anticipated long term performance and risk associated with discontinuing operations and maintenance are acceptable. This analysis is a key part of the permitting process.

2) *What evidence is there that a tailings dam could be built to last the duration of time you believe necessary to protect the wetlands?*

- Clearly, there has not been a modern tailings dam in successful operation for the timescales being considered in the BBWA, i.e., hundreds of years. That does not mean that a tailings dam cannot be built for such duration. As stated in both of Geosyntec's review letters, as well as in the responses above, a successful project will require good design, construction, operations, and maintenance throughout its anticipated lifetime. There are ancient human structures that have been in existence for thousands of years. Imagine the Egyptian pyramids or the Roman aqueducts if they had been maintained through the years.

3) *Since the timescales of human institutions are rarely counted in thousands of years, and the need to maintain tailings dams extends well into that timeframe, please explain the most effective means, in your opinion, to communicate risk around a structure such as a tailings dam to insure that future generations understand that the dam must not be breached.*

- The issue of perpetual management of the residuals from mining is again one of the key issues to be addressed during the permitting process. The long-term management of the TSF will require a plan that includes discussion of risk communication to communities potentially impacted by any unplanned releases from the storage facility. Appropriate detection and reporting systems must be approved by the permitting agency to ensure that information is available on the continued performance of the tailings storage system. There are other examples of long-term storage of waste residuals that must be managed over generations. Commercial, industrial and sanitary landfills have been in existence since the industrial revolution, and modern management systems are designed to ensure continued and safe containment of the materials, including management of seepage and leachate from the waste storage unit. Most facilities managed under the RCRA statutes also contain solid waste management units that require a long-term management plan. Risk communication plans are an essential component of land use controls and other institutional methods established to ensure safe long-term storage of waste residuals. The long-term management of residuals from the mining activity will be a key part of the permitting process for a mine in Alaska.

4) *What role would electricity play in maintaining the safety, security and environmental performance of the mining operation? If there were an electrical failure lasting weeks or months, while the mine is still active, what potential effect could that have on waste management? After the mine is closed, would there be any continuing need for pumps (or other control devices) and electricity?*

- These types of questions regarding redundant equipment and power generation in the event of an outage are all appropriate for the formal regulatory review phase once a formal mine plan has been established and the detailed components of the design are presented. Redundancies in the system, including backup wastewater storage and backup power, will almost certainly be included in the design. Based on a formal evaluation of the risks, suitable measures can be put in place to mitigate those risks to the satisfaction of the regulatory agencies. Some form of pumping, and hence electricity, will certainly be needed for as long as wastewater treatment and overall water management is needed.

5) *Based on your expert knowledge, please list for the Subcommittee the top environmental threats that would come with a Pebble prospect mine that are either at the edge or beyond the reliable control of existing technology.*

- Based on decades of mining practice around the world, there are no environmental threats that are “either at the edge or beyond the reliable control of existing technology.” All aspects of mining operations that pose threats of releases of toxic materials to the environment can be managed by existing and well established technology. Discharge standards can be met with available technology, with cost the main constraint, not the limits of the technology. “Reliable control” must be defined within the context of regulatory oversight, which defines the types of analytes to be measured, the frequency of the measurements and the reporting process to assure compliance with all permit requirements that define the quality and quantity of discharges to the environment from mining operations. Spill prevention plans will be in place to address any releases of toxic materials. Storm water management plans must also be in place. The TSF must be designed to retain the tailings under the stresses resulting from the Maximum Credible Earthquake. Operator training and continued management diligence will be needed to ensure that treatment systems operate properly and that water management occurs to minimize the potential for overtopping of the TSF under storm events. These details would again be part of the extensive permit review process.

Response to Portions of August 14, 2013 Letter from William Riley

<u>The draft BBWA addresses realistic mining scenarios</u>

<u>Comment:</u>

"I would also point out that in my many years of reviewing and processing mining permit applications and managing NEPA analyses of those proposed projects, the Wardrop report and the water rights applications offer as much or more detail than most mining projects at this phase of what can be a lengthy and very complex permitting process. The Wardrop report details the size of structures and facilities (i.e., the overall footprint) as well as the proposed solid waste management plan and wastewater treatment process."

<u>Response:</u>

As stated in my response to Congressman Broun's first question, the use of the Wardrop report as a surrogate for an actual mine plan misrepresents the level of detail on analysis, design and mitigation that would be included in a plan considered during NEPA permitting review. The Wardrop report explicitly states its purpose as an economic assessment of three development scenarios, and while engineering calculations are needed to estimate the cost of the development, no formal design with engineering documentation is provided for the mine elements that are presented, or the mitigation measures and redundant design features that would be included in the mine plan.

As the Wardrop report does not provide sufficient detail to be a formal mine plan, the BBWA relies heavily on it for sizing of the hypothetical mining scenarios, but has to develop its own engineering evaluations, and those are for a mine assumed to fail that would never be permitted in Alaska.

<u>EPA has used sound science to develop the draft BBWA</u>

<u>Comment:</u>

"Lastly, the expertise that EPA used in developing the BBWA draws from a pool of highly qualified scientists and experts in the following disciplines:

- *plant ecology,*
- *stream fish ecology and habitat,*
- *aquatic ecology,*
- *wetlands and watersheds,*
- *hydrology,*
- *ecosystem modeling,*
- *environmental assessment,*
- *ecological risk assessment,*
- *waste and chemical management,*
- *geotechnical and geoenvironmental engineering,*

- *geology, and*
- *civil engineering/environmental restoration."*

Response:

No one is questioning that a wide range of scientists were involved with the BBWA. My concern, however, is the limited number of engineers tasked with conducting the assessment. For example, the Appendix on water management was not authored by an environmental engineer. The conclusions of the BBWA rest on assuming that failure scenarios for the mine system components are inevitable. Given the importance of the failure scenarios to the predicted impacts to the environment, the staff of the BBWA was noticeably limited in geotechnical, chemical and environmental engineering expertise.

EPA understands modern mining methods and practices

Comment:

"In his testimony, Dr. Kavanaugh asserted that modern mining methods would essentially eliminate the risks of failure as described in the draft BBWA and that EPA simply doesn't understand modern mining methods. I strongly disagree. In Region 10 alone there are mining engineers, geologists and hydrologists who have all worked in the mining industry. In 1995 Region 10 organized a Regional Mining Team to develop a more informed and better coordinated and integrated approach to addressing environmental issues and policies associated with large-scale mining across all EPA programs."

Response:

Mr. Riley misrepresents my written and oral testimony. I never stated that modern mining methods would "eliminate the risks of failure". What I said, as noted in the transcript and in my written testimony, is that modern mining methods will reduce the probability of failures, under any reasonable failure mode (e.g. slope stability problems, overtopping, seismic risks in regards to the TSF) and that modern mining methods include use of design methods that have been tested over time to develop the safest design methods for earthen structures and for process equipment such as water treatment systems. Appropriate safety factors are used to limit the risk of failure under reasonably expected circumstances. EPA's own documents specify that "reasonable" means should be used in constructing mining systems that will have a low probability of partial or complete failure. "*The challenge lies largely in determining with a reasonable degree of certainty what measures are needed to assure that a technically complex operation, which is often highly exposed to the variable forces of nature, will remain in compliance with applicable laws and regulations* *throughout active mining as well as during and following closure.*[2] This very reasonable standard will be the basis for the permit application review by the appropriate regulatory agencies.

Modern mining methods will not reduce environmental impacts to acceptable levels

Comment:

"Dr. Kavanaugh asserts that modern mining methods would assure that the failure scenarios addressed in the draft BBWA would never occur or would at the very least be quickly corrected. Even if this were true, the unavoidable environmental impacts associated with the mining project footprint alone (mine pit, waste rock dumps, tailing storage facilities, access road and other infrastructure) of even the smallest scenario addressed would far exceed the impacts of any CWA dredge and fill permits previously issued in Region 10 or anywhere across the nation."

Response:

This statement is incorrect. I have stated in Geosyntec's submittals and my written and oral testimony that modern design, construction, operations and maintenance can mitigate the failure modes that are presented in the BBWA such that their outcome has a very low probability of occurring. Part of the permitting process would include assessing what level of risk is acceptable, and designing the mine components to meet that level of risk.

The issue of mining footprint impacts is very distinct from the majority of the direction of the BBWA which describes catastrophic failures of the tailings impoundments, water treatment systems, culverts, pipelines, and other facilities, with impacts beyond the mine footprint. The mine will have significant environmental impacts within the footprint, but it should be acknowledged that the mine footprint is a small portion of the overall watershed system draining into Bristol Bay. Through the permitting process, it will be established what mitigation measures must be implemented, and whether the unavoidable impacts are acceptable.

Comment:

"I seriously doubt that any modern mine anywhere in the world has been required, let alone succeeded, to meet such a minute effluent limit on an on-going basis, particularly when the waste stream is of a magnitude as that predicted for Pebble – on the order of 49 million cubic meters per year (approximately 35 million gallons per day) according to the draft BBWA."

Response:

This issue clearly represents a technical challenge to the Pebble Project. Again, however, whether the water-quality based effluent standards can be met, and with what level of reliability, will be the subject of careful evaluations during the permitting process. This issue is exactly why an actual

[2] EPA. 2003. *EPA and Hardrock Mining: A Source Book for Industry in the Northwest and Alaska*. January 2003. Seattle, Washington. Page 2.

project plan must be assessed and why no decisions on the future of the project should be based on the project description in the economic analysis provided in the Wardrop report or on the opinions of non-experts on treatment technologies. The actual mine plan would address this technical challenge by presenting the details of the water treatment technology required to meet any water quality discharge standards. In my opinion, water technologies are readily available to meet any discharge standard specified by the lead regulatory agency overseeing discharge permits in Alaska.

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22 May 2013

Mr. Thomas C. Collier, Esq.
Steptoe & Johnson, LLP
1330 Connecticut Avenue, NW
Washington DC 20036

Subject: Assessment of USEPA Response to Geosyntec's Comments on the Bristol Bay Watershed Assessment

Dear Mr. Collier:

In the summer of 2012, Geosyntec Consultants, Inc, (Geosyntec) was retained by Steptoe and Johnson (Steptoe) on behalf of Northern Dynasty Minerals, Inc (NDM), to provide an independent assessment of the quality of the scientific foundations used by Region 10 of the US Environmental Protection Agency (USEPA) in preparation of the draft report, "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" (USEPA, May, 2012)[1]. At the time, that document, designated by the USEPA as a "watershed assessment" (referred to herein as the Bristol Bay Watershed Assessment (BBWA or "2012 Assessment")[2]) was available for public comment. Geosyntec submitted its independent technical review of the 2012 BBWA to Steptoe on 18 July 2012[3] (referred to herein as the "2012 Review").

At approximately the same time, the USEPA had convened an Independent Peer Review Panel consisting of eleven scientists and one engineer to review the same document. The Peer Review Panel's comments were compiled by Versar, a USEPA contractor, in a Final Peer Review Report dated 17 September 2012[4]. Following receipt of the Peer Review Panel Report, which included a summary of comments received during the public comment period, the USEPA revised the

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[1] USEPA. 2012. *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. External Review Draft. EPA 910-R-12-004a. Seattle, Washington. May 2012.

[2] For this report, the term "BBWA" will refer to the watershed assessment as a whole. "2012 Assessment" will refer to the first draft of the report. "2013 Assessment" will refer to the second draft of the report.

[3] Geosyntec. 2012. *Technical Review of May 2012 Draft Report EPA 910-R-12-004a, An Assessment of Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. Prepared by Geosyntec Consultants, 18 July 2012.

[4] Versar. 2012. 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. Prepared by Versar, Inc., 17 September 2012.

BBWA and on 26 April 2013 released the second external review draft ("2013 Assessment")[5]. The public comment period for the 2013 Assessment extends until 31 May 2013.

In early May, Geosyntec was engaged by Steptoe to perform a limited review of the 2013 Assessment within the short review period. This letter report presents Geosyntec's independent technical review of the 2013 Assessment. Given the shorter timeframe, this review is not exhaustive, draws heavily on the comments from our 2012 Review, and focuses on an evaluation of how the 2013 Assessment addresses issues raised by Geosyntec in our previous review. In fact, in our current review we found that the vast majority of our 2012 comments are still valid and in general, have not been adequately addressed in the new document. As such, we suggest that Steptoe consider this "2013 Review" to consist of both this letter and Geosyntec's 2012 Review. The sections that follow present general themes and specific examples identified by Geosyntec during both reviews that illustrate continued bias and lack of credible scientific analysis of a future mine scenario.

As an over-arching comment, while the USEPA has issued the 2013 Assessment as a second draft, it is for all practical purposes a new document. Volume 1 alone has almost doubled in size from 339 pages in 2012 to 618 pages in 2013. This growth comes from a complete reorganization of the report, removal of a limited amount of material, and addition of significant new technical content, including new and updated analyses. Were additional time available for review, it is likely that significant additional commentary could be provided on the new and revised sections within the 2013 Assessment.

1. THEMES OF GEOSYNTEC 2012 AND 2013 REVIEWS

1.1 <u>Bias by Omission</u>

As with the 2012 Assessment, the 2013 document focuses on "potential impacts" of the Pebble Project on the ecological resources of the Bristol Bay watershed. These "potential impacts" include impacts that may occur during normal development and operation of the mining project, as well as those that may occur should any specific engineering system (e.g. tailings storage

[5] USEPA. 2013. *An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*. Second External Review Draft. EPA 910-R-12-004Ba. Seattle, Washington. April 2013.

facility ("TSF") or pipelines) incur a partial or total failure. Considerable effort was expended by the authors of the BBWA to predict the effects of these potential failures on the ecological resources in the watershed, with particular attention given to the salmonid fish populations. In both 2012 and 2013, the authors failed to consider that modern mining practices are designed to reduce the probability of failures of these engineered systems to some established standard of safety, and to minimize the consequences of any failure scenario with the use of modern monitoring systems, contingency planning as part of a mining operations plan, and the establishment of response systems and strategies to control quickly any releases of hazardous materials at the mine site. By omitting the application of modern mine operating best practices designed to reduce the probability of failures and to mitigate quickly the consequences of such failures, the BBWA is clearly biased towards influencing decisions on the fate of the project by implicitly assuming "worst case" outcomes for operation of most of the engineered systems at the future mine site are inevitable.

1.2 Zero-Risk Framework – A Misapplication of Engineering Design Principles

The BBWA continues to be particularly misleading in addressing the issue of system failures through the use of data on past mining operations to imply by analogy that it is scientifically appropriate to realistically assess the probabilities of system failures. The USEPA has applied this approach for all system elements evaluated in the BBWA, including TSFs, pipelines, culverts, water collection and treatment systems and post closure residuals management systems. The document reflects either an intentional or an uninformed misapplication of modern engineering design principles that would be applied under stringent regulatory oversight, particularly when significant projects are implemented in sensitive ecosystems.

To this point, Appendix I, which identifies mitigation practices for mines, contains the following statements relating to failures of tailings dams:

> *"The failure rate of tailings dams depends directly on the engineering methods used in design and the monitoring and inspection programs in the other mine-life stages."*

> *"Azam and Li (Azam and Li 2010) report that failures in all but Europe and Asia have decreased since 2000; this is attributed to improved engineering practices."*

> *"Data presented indicate that failures peaked to about 50 per decade in the 1960's through the 1980's and has dropped to about 20 per decade over the last 20 years, with the frequency of failure occurrences shifting to developing countries."*

These statements challenge the failure probability premise used by the USEPA, but are relegated to an appendix and barely referenced within the main body of the report.

Properly engineered systems are designed to meet appropriate safety standards commensurate with the nature of the consequences of failure. In no circumstances are engineered systems designed or constructed to eliminate the complete possibility of failure. This “zero-risk” bias is apparent in the use of literature data to suggest that failure of engineering systems is inevitable. The BBWA implies that because failures of TSFs and other engineered systems have occurred elsewhere in the past, such failures are an inevitable outcome of any mining operation. Use of case studies of past failures of engineered systems to predict the probabilities of future failures is inherently flawed, because of different project histories, variability in site characteristics and the evolution and application of improved engineering practices based on “lessons learned.” The use of past failures to predict future probabilities of failures is thus inherently biased toward older technical strategies, past maintenance and inspection failures and/or unique failure modes for the individual case studies.

2. EXAMPLES OF INADEQUACY OF 2013 ASSESSMENT

The attached Table 1 presents a review of how the 2013 Assessment addresses comments raised by Geosyntec in our 2012 Review. The table includes three primary columns as follows:

1. Summary of Geosyntec’s 2012 Review comment;
2. Geosyntec’s evaluation of how the 2013 Assessment responds to that comment; and
3. Geosyntec’s evaluation of the adequacy of the 2013 Assessment’s response.

The comments cover the same focus areas described in the 2012 Review, including:

- Tailings dam failures;
- Dam breach analysis;
- Water collection and treatment failures;
- Pipeline failures;
- Road and culvert failures;
- Seismic environment; and
- Water quality.

The following sections present several examples, most from Table 1, of how the 2013 Assessment consistently fails to address the significant concerns raised in Geosyntec's 2012 Review or identified during this review regarding the scientific credibility of the BBWA.

2.1 Improper use of Historical Tailings Dam Failure Case Histories

The most widely quoted reference in the 2013 Assessment in relation to the historical record of tailings dam failures is the 2001 ICOLD[6] report which documents accidents and failures at 220 tailings dams reported between 1917 and 2000. After removing accidents that did not result in a failure with tailings release, the BBWA reports that 135 TSF failures from the ICOLD database remained. In reviewing these cases, the BBWA correctly interprets the data as indicating that the stability of tailings dams may increase with time. However, in the 2013 Assessment, this assertion is caveated with the following new discussion:

> *"However, failures do occur after operation. In December 2012, the tailings dam at the closed Gullbridge Mine, Newfoundland, failed leaving a gap 50 m wide and the height of the dam (Fitzpatrick 2012). The mine opened in 1967, rehabilitation of the site occurred in 1999, and an inspection in 2010 found that the dam was deteriorating (Stantec Consulting 2011)."*(Pg. 9-4)

The new case history provided is one that can be readily mitigated with appropriate design, construction, operations and management. The Gullbridge Mine was operational between 1967 and 1971. An October 2012 Stantec[7] report, prior to the failure, indicates that the 10 m high tailings dam was in poor condition. There was evidence of past failures and past repairs. Stantec's stability assessment indicated a static factor of safety (FS) of 1.0, indicating very high potential for a slope failure.

The TSFs at Pebble will not be designed or constructed at an FS of 1.0 after closure. As such, the inclusion of this case history clearly demonstrates the bias of the BBWA. Consistent with the intent of the ICOLD report, the best use of failure case histories is *"to learn from them, not to condemn."*

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[6] ICOLD (International Commission on Large Dams). 2001. *Tailings Dams, Risk of Dangerous Occurrences, Lessons Learnt from Practical Experiences.* United Nations Environmental Programme, Bulletin 121.

[7] Stantec. 2012. *Dam Safety Review (DSR), Gullbridge Mine, Newfoundland*. prepared for Government of Newfoundland Labrador, October 26, 2012.

2.2 Overtopping Failure Scenario can be Readily Mitigated with Freeboard

The BBWA (2012 and 2013) points out that among the failure case histories in the ICOLD (2001) report, overtopping is a leading cause of dam failure. As such, even though the probability of failure is low, it is selected as the triggering mechanism for a dam breach at a hypothetical Pebble mine. Based on the probable maximum precipitation (PMP) storm event presented in Box 9-3 (pg 9-14) of the 2013 Assessment, the water surface elevation in the TSF would increase by 0.36 m in the Pebble 2.0 Scenario (Table 6.1, pg 6-10). This increase would be the catalyst for a dam breach by overtopping. With a Pebble 2.0 TSF dam height of 209 m, the 0.36 m freeboard requirement is extremely small (0.2% of the TSF dam height). This freeboard requirement to manage the probable maximum flood (PMF) generated from the PMP will likely be far exceeded in design and operation of the TSF dam, where freeboards will likely be several meters.

While the report does not explicitly state what freeboard height was included in their scenario, it does explicitly state that the storm loads can be mitigated easily with freeboard:

> *"If sufficient freeboard were maintained, it would be possible to capture and retain the expected volume of the PMF in the TSF."* Box 9-4 (Pg 9-15)

The 2013 Assessment is therefore basing their dam failure analysis on an extremely improbable event, once again demonstrating the bias in the report. In fact, the report gives clear indication of this bias:

> *"Although a tailings dam failure is a low-probability event, the probability is not zero."* (Pg. 9-13)

The probability of overtopping may not be zero, but it is extremely small for a modern TSF of this size and importance. Such a small probability of failure does not warrant the alarmist dam breach analysis included in the BBWA.

2.3 Oversimplified and Unreliable Dam Breach Analysis

Geosyntec's 2012 Review pointed out that the HEC-RAS[8] model used for the dam breach

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[8] U.S. Army Corps of Engineers (USACE). 2010. HEC-RAS River Analysis System User's Manual Version 4.1. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center. Davis, California.

analysis in the 2012 Assessment was likely flawed, resulting in an over prediction of flow depth and velocities. A table with questionable data from the 2012 Assessment that was referenced in the Geosyntec comment was removed from the 2013 Assessment, but that was the limit of the changes made.

In fact, the maximum flow depths in the failure scenario have increased dramatically relative to the 2012 Assessment. This appears to be a result of a significant change in the peak discharge rate from the dam breach analysis. For the 2013 Assessment's "Pebble 2.0" dam breach scenario, which assumes breach of a 209 m high tailings dam and release of 20% of the stored tailings, the maximum discharge rate is now 149,300 m^3/s (Table 9-4), greater than 12 times the 2012 maximum discharge of 11,915 m^3/s (Table 4-11) for what is presumably the same failure scenario.

The analysis modeled a dam breach over a 30 km path from the TSF to the confluence of the North Fork Koktuli and South Fork Koktuli Rivers. A comparison of several stations near the end of the analysis show:

- Station 10: maximum flow depth has increased from 8.8 m to 35 m;
- Station 5: maximum flow depth has increased from 8.1 m to 53 m; and
- Station 1: maximum flow depth has increased from 14 m depth to 44 m.

One set of assumptions was made in 2012. A very different set of assumptions was made in 2013, with very different results. Given the limitations of the HEC-RAS model, the coarse nature of the inputs to the model, and the sensitivity of the model to changes in parameters, it is clear that neither result is a reasonable representation of what would actually happen in the very unlikely event of a dam breach. Either full details of the model should be provided in an appendix for review, or the model results should be removed from the report completely.

2.4 Unreliable Sediment Deposition Prediction

Geosyntec's 2012 Review pointed out that sedimentation deposition from the dam breach in the 2012 Assessment was being improperly calculated when the flood wave was at its maximum predicted depth. When river flows are at their maximum flood stage, river velocities are often at their highest, which is not conducive to sediment deposition. The majority of sediment deposition occurs on the receding limb of the flood curve, when river velocities are starting to decrease.

The 2013 Assessment continues to assume that deposition occurs at high velocities, extending out across the width of the inundated area at the peak of the flood wave. Box 9-3 of the 2013 Assessment states:

> *"It was also predicted that deposition could occur in the channel and the floodplain of each section following the maximum predicted flow depth during the peak of the flood wave as the flood and debris flow receded."*

However, for the most part the revised evaluation disconnects sediment depth from the dam breach analysis. Box 9-3 also states:

> *"We assumed that sediment deposition would be greatest near the dam, forming a "wedge" from the lowest elevation of the breach and extending downstream. The calculated sediment depths ranged from 45 to 10 m and extended 1.3 and 3.3 km for the 90-m (Pebble 0.25) and 209-m (Pebble 2.0) dam failures, respectively. … Using this maximum width of inundation, a 0.3-m depth of sediment was deposited on the floodplain and channel."*

Sediment thicknesses are now almost entirely controlled by assumptions:

- Sediment "wedge" up to 45 m thick near the dam, extending at a slope of 15:1 (H:V) (pg. 9-19); and
- Sediment thickness at a constant 0.3 m thick beyond the toe of the "wedge."

If deposition of the sediments from the dam failure is no longer the outcome of the dam breach analysis, its continued inclusion in the BBWA further demonstrates the bias of the document.

2.5 No Accounting for Advances in Technology Relative to Historical Case Studies

Geosyntec's 2012 Review identified that, in relation to mine water collection and treatment system failures, inferences drawn in the report do not account for advances in technology or operational practices between the historical case studies examined and present practices. The 2013 Assessment acknowledges that technological advances exist, but then dismisses them with the following discussion:

> *"The use of data from the historical, operational records of mines, pipelines, and roads is necessary but controversial. It is essential and conventional for risk assessments to use the history of a technology to estimate failure rates. However, developers argue, with*

> *some justification, that the record of older technology is not relevant because of technological advances. Despite advances, no technology is perfect, and rates of past failures may be a better guide to future outcomes than the expectation that developers can design a system that will not fail. A classic example is the NASA space shuttle program, which denied the relevance of the failure rate of solid rocket boosters and declared that the shuttle's rate of failure on launch would be one in a million. The Challenger failure showed that the prior failure rate was still relevant, despite updated technology." (Pg. 2-4)*

The 2013 Assessment acknowledges technological advances exist and then uses an example of a very complex and sophisticated system from the NASA space shuttle program to show that even with "*updated technology*" that the "*prior failure rate was still relevant*." The technology used in mine water collection and treatment does not approach the same level of complexity or sophistication as the NASA space shuttle. Similarly, the years of operating experience in the mining industry far exceed the years of experience with space travel. The comparison to NASA further demonstrates the bias in BBWA.

2.6 Unreasonable Pipeline Release Scenario

Geosyntec's 2012 Review pointed out that the pipeline release scenario, which incorporated an assumption of 14 km between isolation valves, resulted in unrealistically high release volumes as 14 km worth of concentrate drained by gravity into the creek. Proper design would include more frequent and strategically placed points of isolation, which would work in concert with automatic leak detection to minimize potential leakage along critical stretches of the pipeline. The 2013 Assessment removes this 14 km scenario. In its place, they include the following scenario:

> *"In the concentrate pipeline failure scenarios, a single complete break of the pipeline would occur at the edge of the stream, just upstream of an isolation valve. These valves would be placed on either side of major crossings (Ghaffari et al. 2011) and could be remotely activated. Pumping would continue for 5 minutes until the alarm condition was assessed and an operator shut down the pumps. The estimated total slurry volume draining to the stream would equal the pumped flow rate times 5 minutes, plus the volume between the break and local high point in the pipeline (i.e., the nearest watershed boundary) (Table 11-2). During the entire spill, gravity drainage governs the flow rate based on calculations for free-flowing pipes."* (Pg. 11-8)

The 2013 Assessment replaces one unjustified scenario with another. The assumption that the *"volume draining to the stream would equal the pumped flow rate times 5 minutes, plus the volume between the break and the local high point in the pipeline (i.e. the nearest watershed boundary)"* completely disregards proper planning and design for the stream crossings. By forcing the failure upstream of the isolation valve and still allowing all of the spilled material to enter the creek, the existence of the isolation valves and any other features that might be designed to protect the streams from failures on land are made obsolete. If the topography and alignment are such that this extreme scenario could exist, unlikely as it may be that a failure would occur in exactly the worst place for the creek, other engineering and/or operational controls can be established to mitigate against it and protect the environment.

2.7 Escape of Leachate from Waste Rock Piles is Overpredicted

The 2013 Assessment includes a new analysis of leachate generation from waste rock piles that was not discussed in the 2012 report, presented as follows:

> *"The mine scenarios (and the plan put forth for Northern Dynasty Minerals in Ghaffari et al. 2011) do not include liners for the waste rock piles. Instead, leachate within the pit's drawdown zone would be captured and pumped to the WWTP. Outside the drawdown zone, half the leachate would be captured by extraction wells or other means and the rest would flow to surface waters. This is considered reasonable given the likelihood that water would flow between wells and below their zones of interception in the relatively permeable overburden materials and upper bedrock. Wells would not catch all flows from the mine site given its geological complexity and the permeability of surficial layers. As a result, 84% of PAG leachate and 82% of total waste rock leachate would be captured by the pit and the wells for the Pebble 2.0 mine."* (Pg. 8-12)

The statement that half (50%) of the leachate from waste rock outside of the leachate zone will escape and flow to surface waters is unsubstantiated. While the 2013 Assessment references the Wardrop (2011)[9] (i.e. Ghaffari et al., 2011) report, it fails to include the discussion in the report where it is stated that a low permeability cutoff wall will be installed around the waste rock piles and extraction wells will be installed within the cutoff wall to capture water and leachate

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[9] Wardrop. 2011. *Preliminary Assessment of the Pebble Project, Southwest Alaska.* Prepared for Northern Dynasty Minerals Ltd., February 15, Prepared by Wardrop (A Tetra Tech Company), Vancouver, BC. [Note: This report is referenced as Ghaffari et al. 2011. in the BBWA]

infiltrating below the waste rock piles. This system can be optimized by adding wells, increasing pumping rates, and/or installing cutoff walls deeper in order to achieve significantly more than 50% capture. In tandem with proper management of potentially acid generating (PAG) waste rock to maximize its placement within the drawdown zone, the capture of PAG waste rock leachate can be close to 100%.

3. SUMMARY

As with its predecessor, the 2013 Assessment conceptualizes the important engineered components of a large mining project, but fails to provide a risk analysis that: a) is based on data applicable to the mine scenario, b) yields reasonably accurate estimates of probability and implications of failure for all the mine components, and c) accounts for modern mining design and operations strategies that would reduce the probability and consequences of low probability failure events. Geosyntec continues to assert that these limitations raise significant concerns on the scientific credibility of the BBWA and the appropriateness of using this document to inform stakeholders on the future of mining in the Bristol Bay watershed.

Sincerely,

Michael Kavanaugh, PhD, PE, NAE
Senior Principal

Christopher Hunt, PhD, PE, GE
Associate

Attachments: Table 1 – Evaluation of How the 2013 Assessment Responds to Geosyntec's 2012 Comments

Copies to: Mr. Bruce Jenkins, Northern Dynasty
Mr. Stephen Hodgson, Northern Dynasty

Table 1: Evaluation of How the 2013 Assessment Responds to Geosyntec's 2012 Comments

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
TAILINGS DAM FAILURES			
2.1	Example case histories of TSF failures are either not relevant to Pebble, or their failure modes can be readily mitigated through proper design, construction, operations and management.	A preamble has been added to the presentation of examples of TSF failures (Box 9-1), which states: 9-3 *"The tailings dam failures below illustrate the characteristics and potential consequences of a tailings dam failure. The details of the design, construction, or operation of any tailings dams constructed for mines in the Bristol Bay watershed would not be the same as these mine tailings dams, but these examples demonstrate that tailings dam failures can occur, and illustrate how these failures may affect downstream areas. In addition, the dams in these failure examples were significantly smaller than the dams in our mine scenarios."*	While the response recognizes that "details" of design, construction and operation at Pebble will be different than those in the TSFs that failed, the original 2012 comment remains true. The four failure examples stem from poor construction, poor operations, and/or poor design. Therefore, they are not relevant to a TSF of the caliber that will be proposed at Pebble. If these case histories are to remain in the report, they should be presented as lessons from the past. The lessons learned from those failures and how the failure modes can be prevented should be included in the report. Much of that discussion is included in Geosyntec's 2012 report.
2.2	Perhaps the most widely quoted reference in relation to the historical record of tailings dam failures is the 2001 ICOLD[1] report which documents accidents and failures at 220 tailings dams reported between 1917 and 2000. In the 2012 Assessment, after removing accidents that did not result in a failure with tailings release, 135 TSF failures from the ICOLD database remain. No significant attempt is made to interpret the implications of these failure case histories on the hypothetical mine scenario. Only the total number of failures is used when evaluating probabilities of failure. … It is our opinion that all of these failure mechanisms can be mitigated with proper investigation, design, construction, operations and maintenance, and oversight. Consistent with the intent of the ICOLD report, we consider that it is more appropriate to use these case histories "*to learn from them, not to condemn.*"	The use of the ICOLD data, now summarized in Table 9-1, remains unchanged in the 2013 Assessment. The interpretation in the 2012 Assessment that the ICOLD data indicate that the stability of tailings dams may increase with time is now caveated with the following new discussion: 9-4 *"However, failures do occur after operation. In December 2012, the tailings dam at the closed Gullbridge Mine, Newfoundland, failed leaving a gap 50 m wide and the height of the dam (Fitzpatrick 2012). The mine opened in 1967, rehabilitation of the site occurred in 1999, and an inspection in 2010 found that the dam was deteriorating (Stantec Consulting 2011)."*	The ICOLD data continues to be presented without recognition that these historical failures are not directly applicable to a modern mine. Consistent with the intent of the ICOLD report, we continue to consider that it is more appropriate to use these case histories "*to learn from them, not to condemn.*" Additionally, we note that the new case history provided is one that can be readily mitigated with appropriate design, construction, operations and management. The Gullbridge Mine was operational between 1967 and 1971. An October 2012 Stantec[2] report, prior to the failure, indicates that the 10 m high tailings dam was in poor condition. There was evidence of past failures and past repairs. Stantec's stability assessment indicated a static factor of safety (FS) of 1.0, indicating very high potential for a slope failure. The Pebble TSFs would not be designed or constructed to sit at an FS of 1.0 after closure. As such, what is the purpose of including this case history without focusing on the lessons to be learned?

[1] ICOLD (International Commission on Large Dams). 2001. *Tailings Dams, Risk of Dangerous Occurrences, Lessons Learnt from Practical Experiences.* United Nations Environmental Programme, Bulletin 121.
[2] Stantec. 2012. *Dam Safety Review (DSR), Gullbridge Mine, Newfoundland*. prepared for Government of Newfoundland Labrador, October 26, 2012.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
2.2	The probability of failure discussed in the 2012 Assessment would be one tailings dam failure for every 2,000 mine years. This probability is not relevant to a modern mining project. An analysis that simply utilizes a retrospective failure rate to estimate future failures at a modern mining site significantly exaggerates the likelihood of a TSF failure, and therefore results in a biased assessment of future outcomes.	The report has added two new caveats in relation to these data: 9-7 *"It is difficult to estimate the probability of low-frequency events such as tailings dam failures, especially when every tailings dam is a unique structure made of natural materials and subject to its individual loading conditions."* 9-7 *"The historical frequencies of tailings dam failures presented above may be interpreted as an upper bound on the failure probability of a modern tailings dam. Morgenstern (2011), in reviewing data (Davies and Martin 2009), did not observe a substantial downward trend in failure rates over time. However, improvements in the understanding of dam behavior, dam design, construction techniques, construction quality control, dam monitoring, and dam safety assessment would be expected to reduce the probability of failure for dams designed, constructed, and operating using more modern or advanced engineering techniques."*	The revised report recognizes the uniqueness of each dam and the improvements in the practice, but this does not go far enough to counter the bias inherent in the *"1 tailings dam failure every 2,000 mine years"* discussion. Additionally, we do not agree that these retrospective failure statistics represent an upper bound on failure probability for modern mining practices. Appendix I of the 2013 Assessment, includes the following statements: *"The failure rate of tailings dams depends directly on the engineering methods used in design and the monitoring and inspection programs in the other mine-life stages."* *"Azam and Li (Azam and Li 2010) report that failures in all but Europe and Asia have decreased since 2000; this is attributed to improved engineering practices."* *"Data presented indicate that failures peaked to about 50 per decade in the 1960's through the 1980's and has dropped to about 20 per decade over the last 20 years, with the frequency of failure occurrences shifting to developing countries."* Unfortunately, Appendix I, which addresses mitigation practices for mines, is relegated to an appendix and is barely referenced within the main body of the report.
2.3	Performing a review of tailings dams that are successful is challenging, as the literature focuses more on problems than success stories. However, the literature does provide documentation related to several recent earthquakes that have subjected modern tailings dams to significant stresses. The following four case histories[3] of large active tailings dams, while certainly not an exhaustive review, do indicate that analogies to seismic risks at the Pebble site exist showing that applying modern design, construction, and operations and management practices can result in successful performance under significant stress with no, or minimal, damage reported.	The only indication within the 2013 Assessment that tailings dams can perform adequately was also in the 2012 Assessment: 9-7 *"Very few existing rockfill dams approach the size of the structures in our mine scenarios, and none of these large dams have failed."*	No new discussion in the 2013 Assessment addresses the comment made by Geosyntec.
NEW	N/A	The 2013 Assessment expands on the discussion of probability of TSF failure by performing a statistical evaluation assuming that the TSFs at Pebble will be constructed as Class II (standard engineering practice) or Class I (state-of-the-practice engineering) facilities. Starting from base rates of 1 in 10,000 (Class II) and 1 in 1,000,000 (Class I) dam year probabilities of slope failure, the 2013 Assessment multiplies these values by four to account for other modes of failure, by eight to account for eight total dams at Pebble 6.5 buildout, and follows an exponential distribution to predict failure rates at 1,000 years of 96% (Class II) and 3% (Class I).	This statistical analysis oversimplifies a very complex process. At each step of the way, the assumptions can introduce significant error and bias. Had the authors of the reference document (Silva et al., 2008)[4] which was used to obtain the starting failure probabilities (e.g. 1 in 10,000 for a Class II dam) been asked whether they considered their method suitable for predicting a 96% failure rate for a TSF constructed with standard engineering practices, they would most likely disagree. We also note that, as described in our 2012 report, the Pebble TSFs will almost certainly be designed and constructed to Class I standards, consistent with a State of Alaska "High Hazard" classification, and hence the 96% failure rate is not only an unreliable statistic, it is not relevant.

[3] Four cases described by Geosyntec (2012) include Tranque Ovejeria and Tortolas in Chile, Tranque Caren in Chile, Antamina Copper-Zing Mine Tailings Dam in Peru, and Fort Knox Gold Mine Tailings Dam in Alaska.
[4] Silva, F. T., T. W. Lambe, and W. A. Marr. 2008. *Probability and Risk of Slope Failure*. Journal of Geotechnical and Geoenvironmental Engineering 134:1691–1699.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
DAM BREACH ANALYSIS			
2.4.1	The Manning's friction coefficient was increased to *"better reflect the influence of sediment-rich water during tailings dam failure"* (pg. 4-53). However the 2012 Assessment does not supply the reader with information as to how they evaluated the appropriate Manning's coefficient, nor do they state the value used. The implications of changes in model parameters would likely be significant given the scale and likely sensitivity of the analysis.	The 2013 Assessment now states: 9-21 *"When applied to tailings dam failure events, it is appropriate to increase channel roughness coefficients to better emulate flow characteristics of concentrated sediment flows. Manning's n = 0.2 for the channel and 0.6 for the floodplain were selected."*	The 2013 Assessment does now state what Manning's n was used. However the report does not provide any analysis or justification for these numbers. In addition the report does not indicate if multiple model runs were run to evaluate sensitivity of model results to Manning's n, as recommended in the original comments.
2.4.2	The analysis in the 2012 Assessment relies on a very coarse 30 meter digital elevation model (DEM) to develop channel bathymetry (pg. 4-53). The coarse nature of the 30 meter DEMs does not account for channel complexity in the floodplain where side channels or wider braided channels are only activated during floods and are available for sediment deposition. Off channel wetlands and watercourses are also missed. The lack of channel complexity and channel morphology oversimplifies the channel roughness and leads to river channels characterized as too "clean" and "smooth." As a result the coarse model very likely over predicts flows, velocities and sediment transport relative to what would be expected in reality (Crosby, 2006)[5].	There is no significant change from 2012. The 2013 Assessment continues to rely on the coarse 30 meter DEM.	The 2013 Assessment does not address Geosyntec's 2012 comment. The analysis continues to be based on the use of a coarse 30 meter DEM (Box 9-4, pg. 9-15). In addition, we note the use of this coarse DEM has now expanded. On Page 3-20 of the 2013 Assessment, the authors discuss conducting a flow analysis using the DEM data to establish the gradient of streams and the channel morphology. The report (pg. 3-20) also uses the DEM data to evaluate the valley gradient for the stream network. This would result in grossly misrepresenting stream gradients as: • The 30 meter DEM grid resolution is too coarse, and • In reality, high gradient streams are a step and pool system and NOT a straight shot down the valley floor. One must look at the hydraulically effective slope which is much lower. Note that this calculated stream gradient was also used to evaluate slopes along the transportation corridor at stream crossings (pg. 10-15).
2.4.3	The lateral extent of the cross-sections in the HEC-RAS model in the 2012 Assessment were likely insufficient, resulting in increased flow depth and higher velocities (Table 4-13, pg. 4-59).	The 2013 Assessment does not address this comment and no longer includes the cited table from the 2012 Assessment. We note that the maximum flow depths have increased dramatically relative to the 2012 Assessment. This appears to be a result of a significant change in the peak discharge rate from the dam breach analysis. For the 2013 Pebble 2.0 scenario, the maximum discharge rate is now 149,300 m^3/s (Table 9-4), greater than 12 times the 2012 maximum discharge of 11,915 m^3/s (Table 4-11) for what is presumably the same failure scenario. At station 10 (formerly station 9.4) maximum flow depth has increased from 8.8 m to 35 m. For station 5 (formerly 5.4) maximum flow depth has increased from 8.1 m to 53 m. For station 1 (formerly 0.6) maximum flow depth has increased from 14 m depth to 44 m.	The 2013 Assessment does not address Geosyntec's 2012 comment. More importantly, the extraordinary change between the 2012 and 2013 analysis is evidence that the dam breach analysis should not be relied upon. One set of assumptions was made in 2012. A very different set of assumptions was made in 2013, with very different results. Given the limitations of the HEC-RAS model, the coarse nature of the inputs to the model, and the sensitivity of the model to changes in parameters, it is clear that neither result is a reasonable representation of what would actually happen in the very unlikely event of a dam breach. Either full details of the model should be provided in an appendix for review, or the model results should be removed from the report completely.

[5] Crosby, D. A. 2006. *The Effects of DEM Resolution on the Computation of Hydrologically Significant Topographic Attributes*. Master's Thesis. University of South Florida. Tampa, Florida.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
2.4.4	The mine tailings dam breach run-out scenarios in the 2012 Assessment are modeled to a distance of only 30 km and the analysis then utilizes a tailings run-out regression equation to calculate total mine tailings travel distances beyond the last segment of the model (pg. 4-57). Switching from a simplistic sediment transport approach to an even more simplistic regression equation once the mine tailings reach the confluence of the North Fork Koktuli and South Fork Koktuli Rivers only adds to the uncertainty in the estimates of the distance of sediment transport**.**	The 2013 Assessment did not address this comment as the HEC-RAS model continues to end at a distance of 30 km (Box 9-5, pg 9-21), followed by use of the tailings run-out regression equation (pg 9-20).	The 2013 Assessment does not address Geosyntec's 2012 comment.
2.4.5	Sedimentation of the dam break flood wave in the 2012 Assessment was calculated when the flood wave was at its maximum predicted depth (pg. 4-57). When river flows are at their maximum flood stage, river velocities are often at their highest, which is not conducive to sediment deposition. The majority of sediment deposition occurs on the receding limb of the flood curve, when river velocities are starting to decrease.	As described in Box 9-5, the 2013 Assessment provides a very different evaluation of sediment deposition. *"We assumed that sediment deposition would be greatest near the dam, forming a "wedge" from the lowest elevation of the breach and extending downstream. The calculated sediment depths ranged from 45 to 10 m and extended 1.3 and 3.3 km for the 90-m (Pebble 0.25) and 209-m (Pebble 2.0) dam failures, respectively. It was also predicted that deposition could occur in the channel and the floodplain of each section following the maximum predicted flow depth during the peak of the flood wave as the flood and debris flow receded. Using this maximum width of inundation, a 0.3-m depth of sediment was deposited on the floodplain and channel."*	The 2013 Assessment continues to assume that deposition occurs at high velocities, extending out across the width of the inundation wave at the peak of the flood wave. However, for the most part the revised evaluation disconnects sediment depth from the dam breach analysis. Sediment thicknesses are now almost entirely controlled by assumptions: • sediment "wedge" up to 45 m thick near the dam, extending at a slope of 15:1 (H:V) (pg. 9-19); and • sediment thickness at a constant 0.3 m thick beyond the toe of the "wedge." This revised approach raises the following question: What is the purpose of the dam breach analysis?
2.4.6	The Hjulstrom curve was used in the 2012 Assessment to evaluate sediment transport velocity (pg. 4-57). 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 report.	The 2013 Assessment did not address this comment as the reference to Hjulstrom remains in the text of Box 9-5 (pg. 9-21).	While the 2013 Assessment does not address the comment, the revised approach to sediment deposition, which is based on assumption and not on analysis, makes our 2012 comment, and the continued use of the Hjulstrom curve in Box 9-5 of the 2013 Assessment, irrelevant.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
WATER COLLECTION AND TREATMENT FAILURES			
3.1	A review of the water collection and treatment system failures in the 2012 Assessment show how both the language and the evaluations associated with the assessment are often misleading, and generally exaggerate the impacts of system failures, as well as the likelihood of potential failures. The first inadequacy is the lack of a clear definition of what constitutes a "failure" of the water collection and treatment system. The examples and language used throughout the document suggest that the temporary loss of a system component is considered a "failure" and the report presents such a failure as a virtual certainty. The report overlooks the fact that failure of a minor system or component (e.g. a mechanical pump breakdown or an electrical instrumentation failure) can be quickly and relatively routinely addressed, and is thus unlikely to cause a release of hazardous substances or result in any material environmental impact. Also, no distinction is made between a minor release that causes no environmental impacts outside of the site boundaries and a major release that could result in potentially environmentally significant impacts beyond the site.	The 2013 Assessment reorganizes the work relating to water collection and treatment, although no clear definition of "failure" is provided in the revised report. 8-1 "*In addition, we evaluate a WWTP failure scenario, in which the system releases untreated wastewater. This failure represents one potential failure among many accidents and failures that could occur.*" 8-19 "*There are innumerable ways in which wastewater treatment could fail under the mine scenarios in terms of failure type (e.g., breakdown of treatment equipment, ineffective leachate collection, wastewater pipeline failure), location, duration, and magnitude (e.g., partial vs. no treatment). Box 8-1 presents an example wastewater collection failure, and mechanisms of treatment failure are discussed in Box 8-2. To bound the range of reasonable possibilities, we assess a serious failure in which the WWTP allows untreated water to discharge directly to streams. This type of failure could result from a lack of storage or treatment capacity or treatment efficacy problems. Chronic releases would occur during operation if a lengthy process were required to repair a failure. We evaluate potential effects of this type of failure using the following assumptions.*"	As with the 2012 Assessment, the 2013 Assessment is inadequate as there is no clear definition of what constitutes a "failure" of the water collection and treatment system. The examples and language used throughout the document suggest that failure modes are "innumerable" and the release of untreated water is a certainty. Enumerating and assessing potential failure modes, and developing an appropriate management strategy for each, is expected to be a part of the mine design process. By presenting a "*serious failure*" that "*allows untreated water to discharge directly to streams*", the Assessment asserts this outcome as a "*reasonable possibility*", without any justification. Such an outcome, in reality is of extremely low probability as it would constitute direct violation of wastewater discharge regulations with severe penalties imposed. To call this a "reasonable probability" is a gross mischaracterization of wastewater treatment practices at modern mines. The Assessment is very misleading in that, taken as a whole, it leaves the reader with the impression that the long-term release of untreated waters and leachates are a certainty, even during routine operations.
3.1	The 2012 Assessment repeatedly presents the likelihood of a failure of the water collection and treatment system as having a "*high probability*" and "*certain*" events while admitting a lack of "…data on the frequency of failures to fully collect and properly treat waters from mining operations." Hence, the report relies on qualitative probabilities without supporting documentation. Similarly, the report concludes that failures are "*highly likely*" to result in releases of untreated leachate for up to months at a time. These assumptions are not valid and fail to consider applications of modern process engineering systems used in mining operations today for water collection and treatment.	The 2013 Assessment continues to present failure of the water management systems as a certainty. For example: 2-4 "*Thus, in this assessment we choose failure rates that are most relevant and interpret them cautiously, using them to provide an upper bound estimate of future failure rates.*" 8-22 "*The USEPA has observed that some operators continue to operate when they know that treatment is ineffective and not meeting standards. Hence, the record of analogous mines indicates that releases of water contaminated beyond permit limits would be likely over the life of any mine at the Pebble deposit. The probability of the specific WWTP failure analyzed here cannot be estimated. It is improbable in that it requires that wastewater not be treated and not be diverted to storage. However, it is plausible that such an event would result from equipment failures, inadequate storage or human errors. It is more likely that a partial failure (e.g., incomplete treatment) would occur, but any one of the innumerable incomplete treatment scenarios is also unlikely. Hence, the WWTP failure scenario analyzed here is a reasonable bounding case.*" 14-5 "*Collection and treatment failures are highly likely to result in release of untreated or incompletely treated leachates for days to months, but the water would be less toxic due to elimination of PAG waste rock.*"	The original section in the 2012 Assessment has been re-written. The failure rates used are acknowledged as being an "*upper bound*" or worst-case set of circumstances. By only discussing the "*upper bound estimates*" the document continues to mislead and exaggerate the most probable, or expected value, of the outcomes. Treatment failures are presented as a certainty. Similarly, discharges in excess of permit limits are also presented as likely. The Assessment uses the example, without reference, of mine operators who knowingly operate with ineffective treatment. This is another example in the BBWA of exaggerating the probabilities of system failures to raise fears of unavoidable impacts, and emphasizing worst case scenarios that are highly improbable in a modern mine.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
3.1	In Box 4-1 the 2012 Assessment 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. The cumulative effect of four worst-case factors (unlimited oxygen supply, higher concentration of metals in the waste rock, high leaching rates due to small grain size, and high water contact due to the absence of preferential flowpaths) sets an overly conservative bound on the hazardous characteristics of the leachate quality. Use of the additive result of multiple concurrent worst-case factors, represents an unreasonable overstatement of the potential impacts of leachate releases. A risk analysis based on these assumptions cannot be well supported scientifically.	The section has been re-written; this Box scenario has been replaced by three additional Box discussions which provide an overview of the use of best management practices, regulations, and financial assurances required: Box 4-1 "*Reducing Mining's Impact*" ; Box 4-2 "Per*mitting Large Mine Projects in Alaska*"; and Box 4-3 "*Financial Assurance*".	The inclusion of discussion of best management practices would help the Assessment to be more balanced except that these Box references are later negated elsewhere in the document. The Assessment later asserts that most mines do not comply with regulations and that in the past financial assurances have been insufficient and that taxpayers have been left with closure costs. 6-36 "*In the past, however, financial assurance often has not been adequate, and taxpayers have been left with substantial cleanup costs (USEPA 1997). This may be changing, as agencies update bonding requirements to reflect cleanup costs more accurately, but projecting these costs far into the future is a difficult task.*" 8-22 "*The USEPA has observed that some operators continue to operate when they know that treatment is ineffective and not meeting standards. Hence, the record of analogous mines indicates that releases of water contaminated beyond permit limits would be likely over the life of any mine at the Pebble deposit.*"
3.1	The inferences drawn in the report also do not account for advances in technology or operational practices between the historical case studies examined and present practices. The assessment acknowledges that some case studies cited incorporated historical and outdated mining practices that would not be allowed under current mining laws. Several passages of text use language that are not technically correct and, as a result, can be confusing or misleading.	Technological advances are acknowledged to exist, and are then cited as being additional sources of unforeseen and unpredictable failures. 2-4 "*The use of data from the historical, operational records of mines, pipelines, and roads is necessary but controversial. It is essential and conventional for risk assessments to use the history of a technology to estimate failure rates. However, developers argue, with some justification, that the record of older technology is not relevant because of technological advances. Despite advances, no technology is perfect, and rates of past failures may be a better guide to future outcomes than the expectation that developers can design a system that will not fail. A classic example is the NASA space shuttle program, which denied the relevance of the failure rate of solid rocket boosters and declared that the shuttle's rate of failure on launch would be one in a million. The Challenger failure showed that the prior failure rate was still relevant, despite updated technology.*"	The report acknowledges technological advances exist and then uses an example of a very complex and sophisticated system from the NASA space shuttle program to show that even with "*updated technology*" that the "*prior failure rate was still relevant*." The technology used in mine water collection and treatment does not approach the same level of complexity or sophistication as the NASA space shuttle. Similarly, the years of operating experience in the mining industry far exceeds the years of experience with space travel. The comparison to the NASA event simply highlights the bias in the BWWA in assessing the potential for failure of any engineered system.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
3.1	The 2012 Assessment states: "*Following the termination of mine operations, collection and treatment may cease immediately (premature closure) or may continue for some period (planned closure), but eventually will cease (perpetuity). If the water is nontoxic, in compliance with all criteria and standards, and its composition is stable or improving, the collection and treatment system may be shut down under permit. Otherwise, treatment would continue until institutional failures ultimately resulted in abandonment of the system, at which time untreated leachate discharges would occur.*" (pg. 6-36) This statement assumes that institutional controls will fail at some time and management of water residuals would cease, when considering "*perpetuity*". First, this is a contingency outcome that would be evaluated in the permitting process. All closures, referred to in the report as both "*planned*" and "*unplanned*," are planned for during the permitting process. This statement is misleading because it does not differentiate between leachate that is collected during mine operations and that which may be generated during the "in perpetuity" timeframe. If institutional failures result in the eventual abandonment of the water collection and treatment systems, a reasonable expectation is that by this time the site would have executed the closure plan and that the leachate quality would be stable or improving each year. In contrast, the BBWA implies that it is inevitable that untreated leachate will eventually be discharged to the natural environment, resulting in a significant environmental impact. Such speculation on future outcomes is not consistent with accepted risk analysis practice, as a "reasonable" time frame must be considered.	The 2013 Assessment continues to assert the eventual release of untreated leachate is a certainty but now makes reference to the fact the water would be less toxic due to the elimination of PAG rock. 8-2 "*Following the termination of mine operations, it is expected that water collection and treatment would continue for waste rock and tailings leachates. If the water is nontoxic, in compliance with all criteria and standards, and its composition is stable or improving, the collection and treatment system may be shut down under permit. Otherwise, treatment would continue in perpetuity—that is, until untreated water quality was acceptable or institutional failures ultimately resulted in abandonment of the system. If the mine operator abandons the site, the State of Alaska should assume operation of the treatment system; if both the mine operator and the State of Alaska abandon the site, untreated leachate would flow to streams draining the site.*" ES-18, 14-5 "*When water is no longer managed, untreated leachates would flow to the streams. However, the water would be less toxic due to elimination of PAG waste rock.*"	Geosyntec's 2012 comments remain unchanged. The 2013 Assessment continues to refer to the discharge of untreated leachate at some future state as "*Certain.*" (ES-18, 14-5) If institutional failures result in the eventual abandonment of the water collection and treatment systems, a reasonable expectation is that by this time the site would have executed the closure plan, potentially acid generating (PAG) waste rock would have been processed and tailings placed in the pit below water, many years of post-closure leachate management will have occurred, and the leachate quality would be stable or improving each year.
3.2.2	Figure 4-9B incorrectly depicts a post-closure scenario with no water management. As described in the Wardrop (2011)[6] report, the closure planning process includes long-term water management and financial sureties to ensure that the closure plan will remain funded. Many mine closure plans include a move towards long-term passive management of mine water systems, including surface grading and vegetation to minimize infiltration. These passive methods to reduce leachate generation are sufficiently simple in nature that long term maintenance and the risk of failure can be minimized. The management of tailings and waste rock is expected to stabilize during the active post-closure period such that minimal active management would be required.	Figure 4-9B is replaced by Figure 6.5. The explicit reference to no long-term water treatment is removed from the figure.	The reference to no water treatment being used post-closure is removed from this figure. However, as described previously, the 2013 Assessment continues to make reference to untreated leachate being discharged in perpetuity.

[6] Wardrop. 2011. *Preliminary Assessment of the Pebble Project, Southwest Alaska*. Prepared for Northern Dynasty Minerals Ltd., February 15, Prepared by Wardrop (A Tetra Tech Company), Vancouver, BC. [Note: This report is referenced as Ghaffari et al. 2011. in the BBWA]

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
3.2.3	In the 2012 Assessment a fourth timeframe is considered, post-closure "*in perpetuity*," beyond the "*limited lifetime of human institutions*."(pg 3-5) Consideration of this scenario suggests a broader USEPA policy issue, as there are other facilities, such as closed hazardous and non-hazardous waste landfills, that are intended to remain in perpetuity. Consider the following statements from the 2012 Assessment: "*Further, it is much too soon to know whether mines that are permitted for perpetual water collection and treatment (e.g., the Red Dog Mine in Alaska) can in fact carry out those functions in perpetuity.*" (pg. 6-41) "*…given the relatively ephemeral nature of human institutions over these timeframes, we would expect that eventually monitoring, maintenance, and treatment would cease.*" (pg. 7-14) The report calls into question the ability of the Red Dog Mine operator to meet the obligations of its approved permit for perpetual operation. The ability to operate a water management system for 200 years can only be proven with absolute certainty following 200 years of demonstrated operation. By placing doubt on the ability to operate perpetually, the BBWA creates an unrealistic standard that is impossible to meet.	There is no significant change for 2012. The 2013 Assessment continues to call into question the ability to operate any system "*in perpetuity*". 6-32 "*…need to be maintained for hundreds to thousands of years. It is impossible to evaluate the success of such long-term collection and treatment systems … because these timeframes exceed both existing systems and most human institutions…. The uncertainty that human institutions have the stability to apply treatment for these timeframes applies to all treatment options.*" 8-22 "*…it is much too soon to know whether mines that are permitted for perpetual water collection and treatment (e.g., the Red Dog Mine in Alaska) can actually carry out those functions in perpetuity.*" 13-31 "*In light of the relatively ephemeral nature of human institutions over these timeframes, we would expect that monitoring, maintenance, and treatment would eventually cease, leading to increased release of contaminated waters downstream.*" 14-16 " *Human institutions change. Over the long time span of mining and post-mining care, generations of mine operators must exercise due diligence. Priorities are likely to change…*"	Geosyntec's 2012 comments remain unchanged. By adding new text in additional locations in the 2013 Assessment that cast doubt on the ability to operate in perpetuity, the Assessment continues to create an unrealistic standard that is impossible to meet. The bias of the report remains clear.
3.3	The 2012 Assessment states: "*Our mine scenario represents current good, but not necessarily best, mining practices*." (pg. 4-17) The current practices in use at some porphyry copper mines are the result of years of the evolution in engineering design. Implementing current best practices at some older sites may be hampered by historic mine development decisions and may therefore be limited to mitigation or remediation efforts.	The 2013 Assessment re-asserts that the development scenarios represent plausible mine development scenarios. 6-1 "*These three mine scenarios represent realistic, plausible descriptions of potential mine development alternatives, consistent with current engineering practice and precedent.*"	Geosyntec's 2012 comments remain unchanged. The assumption on the quality of mining practices (i.e. good versus best) that may be applied at a future mine in the Bristol Bay watershed is purely speculative and biases the BBWA. Ultimately, the operational practices will have to conform to a plan approved by the oversight regulatory agencies, and will be designed to meet the unique requirements of the site. All indications are that Pebble will be designed to "best" practices, and yet the 2013 Assessment has not changed their mine scenario to match.
3.3	The 2012 Assessment states: "*During mine operation, collection or treatment of leachate from mine tailings, pit walls or waste rock piles could fail in various ways. This water collection and treatment failure could be continuous (e.g., failure to collect all leachate from the tailings storage facility) or episodic (e.g., failure due to a power loss). In such cases, leachate might enter groundwater and not be collected by the pit sumps or the tailings impoundment's collection system, or could discharge to surface waters directly or through a non-functioning water treatment system.*" (pg. 6-36) No supporting documentation or references are listed in the assessment to support the claims relating to water collection and treatment failure. Neither the "*continuous*" nor the "*episodic*" failures mentioned represent current "*best practices*" for operating mines.	This portion has been rearranged and re-written in the 2013 Assessment. 8-19 "*There are innumerable ways in which wastewater treatment could fail under the mine scenarios in terms of failure type (e.g., breakdown of treatment equipment, ineffective leachate collection, wastewater pipeline failure), location, duration, and magnitude (e.g., partial vs. no treatment). Box 8-1 presents an example wastewater collection failure, and mechanisms of treatment failure are discussed in Box 8-2. To bound the range of reasonable possibilities, we assess a serious failure in which the WWTP allows untreated water to discharge directly to streams. This type of failure could result from a lack of storage or treatment capacity or treatment efficacy problems. Chronic releases would occur during operation if a lengthy process were required to repair a failure. We evaluate potential effects of this type of failure using the following assumptions…Duration of a release could range from a few days to several months, depending on the nature of the failure and difficulty of repair and replacement.*"	Although a range of outcomes is presented, the relative likelihood of each is not given weight in the Assessment. Based on our experience with industrial facilities, most equipment breakdowns would be resolved within hours, some might require a few days for replacement parts to arrive at the site. The only malfunctions that take months to remedy are those that depend on suitable weather to facilitate the repair; these are quite rare and usually temporary measures are constructed to manage the situation during the interim period. The scenario described in the 2013 Assessment is considered extremely unlikely given the multiple redundancies that will be incorporated within the treatment plant system design, and the proposed operational approach where untreated water will be stored in the TSF such that if the treatment plant were to go offline, water would not be transmitted to the plant in the first place.

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3.4	The 2012 Assessment states: *"When a mine reopens after premature closure, the owners may change the mining plan, may not implement the same mitigation practices, or may negotiate new effluent permits. For example, the Gibraltar copper mine in British Columbia was permitted as a zero-discharge operation. When it closed, then reopened under new ownership, it was permitted to allow effluent discharge to the Fraser River, and this permit included a 92-m dilution zone for copper and other metals."* (pg. 4-33) The BBWA appears to suggest the reopening of this mine under a new permit was inappropriate. Updates to the permit are appropriate based on new information and an improved understanding of the risks associated with discharge to the receiving environment. Stakeholder consultation and regulatory approval is required before any such alteration of the discharge permit could take place. This statement overlooks the process that is required to obtain approval of any changes to permit conditions, which includes careful analysis by the lead regulatory agency.	The 2013 Assessment expands on the original text with the following discussion, which includes reference to Fort Knox mine in addition to the Gibraltar Mine. 6-36 *"When a mine re-opens after premature closure, the owners might change the mining plan, implement different mitigation practices, or negotiate new effluent permits. An example is the Gibraltar copper mine in British Columbia. The Gibraltar mine began operations permitted as a zero-discharge operation. However, when it was re-opened under new ownership after having closed prematurely, the new permit allowed treated water to be discharged to the Fraser River with a 92-m dilution zone for copper and other metals. On October 1, 2012, an Alaska Pollution Discharge Elimination System permit authorized the Fort Knox Mine near Fairbanks, Alaska, to discharge wastewater to nearby Fish Creek. Although this mine has never been closed, it was originally designed and permitted in 1994 as a no-discharge facility."*	As per the Geosyntec 2012 report, including these examples in the Assessment continues to suggest the reopening of the Gibraltar mine under a new permit or modifying the discharge permit for the Fort Knox mine was inappropriate. The addition of the Fort Knox example to the 2013 Assessment serves to reinforce the bias in the report. Updates to the permits are appropriate based on new information and an improved understanding of the risks associated with discharge to the receiving environment. Stakeholder consultation and regulatory approval is required before any such alteration of the discharge permit could take place. This statement overlooks the process that is required to obtain approval of any changes to permit conditions, which includes careful analysis by the lead regulatory agency.
3.4	The 2012 Assessment states: *"Water collection and treatment failures may be acute or chronic. A recent example is the overfilling of the tailings impoundment at the Nixon Fork, Alaska, mine that resulted in overtopping of the dam (Box 6-2)."* (pg. 6-36) The Nixon Fork example serves as a warning of the importance of water management at mine sites. Inadequate or inappropriate instrumentation was used to monitor the level in the tailings impoundment. Staff elected to not monitor the freeboard level as the gage was frozen in ice. Additionally, a major change was made to the production process (moving from batch to continuous operation) without an adequate understanding of the consequences to the site water balance and water management. Note that, as described in Box 6-2, for this release it was found that water from the tailings impoundment was not likely to have reached nearby streams.	Box 6-2 was reorganized and renamed to Box 8-1, pg. 8-20. The following concluding statement is added to Box 8-1: *"This case illustrates the diversity of potential failures that can happen and suggests the practical impossibility of predicting all possible failure modes."*	Geosyntec's 2012 comments remain unchanged. Water management is an important component of mine operation. We note however that the addition of the concluding statement is biased in that it indicates that failure modes cannot be predicted. Nothing about the Nixon Fork case indicates a failure mode that could not have been predicted. In reality, the overtopping at Nixon was both predictable and preventable if appropriate effort and oversight had been applied to managing the site's water balance.
NEW	N/A	The 2013 Assessment incorporates a new evaluation of leachate from the waste rock piles around the mine pit, as follows: 8-12 *"The mine scenarios (and the plan put forth for Northern Dynasty Minerals in Ghaffari et al. 2011) do not include liners for the waste rock piles. Instead, leachate within the pit's drawdown zone would be captured and pumped to the WWTP. Outside the drawdown zone, half the leachate would be captured by extraction wells or other means and the rest would flow to surface waters. This is considered reasonable given the likelihood that water would flow between wells and below their zones of interception in the relatively permeable overburden materials and upper bedrock. Wells would not catch all flows from the mine site given its geological complexity and the permeability of surficial layers. As a result, 84% of PAG leachate and 82% of total waste rock leachate would be captured by the pit and the wells for the Pebble 2.0 mine."*	The statement that half (50%) of the leachate from waste rock outside of the leachate zone will escape and flow to surface waters is unsubstantiated. While the 2013 Assessment references the Wardrop (2011) (i.e. Ghaffari et al., 2011) report, it fails to include the discussion in the Wardrop report where it is stated that a low permeability cutoff wall will be installed around the waste rock piles and extraction wells will be installed within the cutoff wall to capture water and leachate infiltrating below the waste rock piles. This system can be optimized to achieve significantly more than 50% capture. In tandem with proper management of PAG waste rock to maximize its placement within the drawdown zone, the capture of PAG waste rock leachate can be close to 100%. This relatively straight forward approach to enhanced leachate collection is standard best engineering practices, a fact that is ignored in the 2013 Assessment.

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PIPELINE FAILURES			
4.1	Pipeline failure rates are being estimated based on questionable statistics and with unreferenced source data. Underlying mathematical analysis is not shown and cannot be verified. Failure data is obtained from the Oil and Gas (O&G) industry with no justification as to its applicability to the mining industry. The underlying classification of failure data (does each population include all of the same failure types?) is not considered. The possibility of using buried piping is ignored, and impact failures / human error are unreasonably reinforced.	Failure rate data are now all referenced and new failure data has been added to the summary Table 11-1. The new failure data is once again from the O&G sector and its applicability to mining failure rates has not been established. The following statement is added relative to relevance to the mining industry: 11-6 *"Although data are insufficient to determine failure probabilities specific to the metal mining industry, the record suggests that pipeline failures at mines are not uncommon. review of 14 operating porphyry copper mines in the United States (including all operating U.S. porphyry copper mines but two that have been operating for less than 5 years) found that all had experienced pipeline spills or accidental releases and that pipeline failures have continued into 2012 (Earthworks 2012)."*	Geosyntec's 2012 comments remain largely unchanged. While data is now referenced and new data has been added, since the underlying analysis is not shown, it is not clear whether the new data should change the conclusions being drawn. The new failure data is once again from the O&G sector and its applicability to mining failure rates has not been established. Reference is made to the inadequacy of the data relative to the metal mining industry, and qualitative reference is made to pipeline failures data in the mining industry; however, as the failure rate used for analysis (0.001 failure/km-yr) did not change from 2012, the mining specific information does not appear to have influenced the evaluation.
4.2	Statistical methods used in the assessment of piping failure rates are of questionable validity. Use of the exponential distribution to model pipeline failures, and assumptions of constant failure rate along the length of a pipe, are inappropriate. The failure rates thus derived (98% chance of line failure over 25 years) are misleading at best.	With the exception of an adjustment for length of the transportation corridor, the 2012 statistical analyses and associated inaccuracies appear to be unchanged.	No adequate response appears to have been provided, and failure rates continue to be misleading.
4.3	The volume of release due to a pipeline failure, as described in the 2012 Assessment, is heavily dependent on the length of pipeline between two isolation points which define the maximum trapped volume which could be released. In Table 4-15, for the concentrate pipeline, the volume of flow over 2 minutes is 5.1 m^3, while the volume between isolation valves is 470 m^3. The 2012 Assessment characterizes this minimum distance as 14 km based on the need to have isolation on either side of every major river crossing and cites the Wardrop (2011) report as support. However, the Wardrop (2011) report (pg. 332) characterizes major river crossings as 600 ft (0.18 km) wide for design purposes. The 14 km assumption thus produces unrealistically high (14 km vs. 0.18 km) representative release volumes in Table 4-15. Proper design would include more frequent and strategically placed points of isolation, which would work in concert with automatic leak detection to minimize potential leakage along critical stretches of the pipeline.	Reference to 14km distance appears to have been removed. The updated spill volume is based on the following scenario: 11-8 *"In the concentrate pipeline failure scenarios, a single complete break of the pipeline would occur at the edge of the stream, just upstream of an isolation valve. These valves would be placed on either side of major crossings (Ghaffari et al. 2011) and could be remotely activated. Pumping would continue for 5 minutes until the alarm condition was assessed and an operator shut down the pumps. The estimated total slurry volume draining to the stream would equal the pumped flow rate times 5 minutes, plus the volume between the break and local high point in the pipeline (i.e., the nearest watershed boundary) (Table 11-2). During the entire spill, gravity drainage governs the flow rate based on calculations for free-flowing pipes."*	The 2013 Assessment replaces one unjustified scenario with another. The 14 km assumption is removed and the associated volume of the spill is also reduced, but an assumption is added that the *"volume draining to the stream would equal the pumped flow rate times 5 minutes, plus the volume between the break and the local high point in the pipeline (i.e. the nearest watershed boundary)."* Once again, the Assessment completely disregards proper planning and design for the stream crossings. By forcing the failure upstream of the isolation valve and still allowing all of the spilled material to enter the creek, the existence of the isolation valves and any other features that might be designed to protect the streams from failures on land are made obsolete. If the topography and alignment are such that this extreme scenario could exist, unlikely as it may be that a failure would occur in exactly the worst place for the creek, other engineering and/or operational controls can be established to mitigate against it.

Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
4.3	Iliamna Lake should not be considered the main receptor for spills since a proportion of spill events will be distant from the lake and/or isolated and cleaned up before reaching a waterway.	An attempt to address this comment appears to have been made in the 2013 Assessment: 11-9 *"Estimated mean velocities of the streams (1.8 m/s for Chinkelyes Creek and Knutson Creek and 1.1 m/s for the Iliamna River) are consistent with those described for these streams (PLP 2011), and are well above the transport velocities. Therefore, the fine sand-sized concentrate would be carried downstream during typical or high flows, even given that the concentrate is denser (3.8 metric tons/m3) than typical rock (2.8 metric tons/m3 for granite) and would move less readily. Concentrate would be deposited in any backwaters, pools, or other low-flow locations. If the spill occurred during a period of high flow, it would be carried downstream immediately, potentially reaching Iliamna Lake within 4 hours (via Chinkelyes Creek and Iliamna River) or 0.5 hour (via Knutson Creek). Because flood flows are a potential cause of pipeline failure at stream crossings, this is a reasonable possibility. If the spill occurred during low flows, concentrate that is not collected would be spread downstream by erosion during subsequent typical or high-flow periods, eventually entering Iliamna Lake."*	The 2013 Assessment described conditions under which transport of spilled product would occur. We note that the extreme failure scenario now has to occur during a period of significant flow in the creek in order for significant product to reach Iliamna Lake. Otherwise it is likely that cleanup operations could isolate the majority of the spilled product. In relation to failure during high flows, the statement that *"because flood flows are a potential cause of pipeline failure at stream crossings, this is a reasonable possibility"* now creates an even more remote possibility that the extreme failure scenario would occur. Such a failure during a flood flow (if the pipe were somehow not protected from such a condition) would most likely occur between the isolation valves, and hence they would shut down and the volume of product released would be far smaller than that assumed in the 2013 Assessment.
ROAD AND CULVERT FAILURES			
5.1	Cited culvert failure rates on the order of 30-66% are not applicable. The 2012 Assessment cites literature supporting culvert failure rates of 30-66% (30% from Price et al. 2010[7], 53% from Gibson et al. 2005[8], 58% from Langill and Zamora 2002[9], and 66% from Flanders and Gariello 2000[10]). In these studies the authors note the issues observed could have been prevented with proper design, installation and/or maintenance. Therefore a project being designed and constructed under current regulations with stringent environmental standards and regulatory oversight should be expected to be executed with much greater care such that fish passage standards are met at each crossing.	The 2013 Assessment has removed the 66% statistic (Flanders and Gariello, 2000). The new range is 30-58%.	Geosyntec's 2012 comments remain essentially unchanged as these case histories are not applicable to a future mine. While the Flanders and Gariello (2000) data were clearly not applicable, it is interesting to note that the 2013 Assessment removes this data set from Alaska, but keeps a data set from Nova Scotia (Langill and Zamora, 2002) which focused on small culverts that never required a permit for construction in the first place.

[7] Price, D. M., T. Quinn, and R. J. Barnard. 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.
[8] Gibson, R. J., R. L. Haedrich, and C. M. Wernerheirn. 2005. *Loss of fish habitat as a consequence of inappropriately constructed stream crossings.* Fisheries 30:10-17.
[9] Langill, D. A. and P. J. Zamora. 2002. *An Audit of Small Culvert Installations in Nova Scotia: Habitat Loss and Habitat Fragmentation.* 2422, Canadian Department of Fisheries and Oceans, Habitat Management Division, Dartmouth, Nova Scotia.
[10] Flanders, L. and J. Gariello. 2000. *Tongass Road Condition Survey Report.* Technical Report No. 00-7, Alaska Department of Fish and Game, Juneau, AK.

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<tr><th>Geosyntec Section</th><th>2012 Geosyntec Comment</th><th>How 2013 Assessment Responds to Comment</th><th>Discussion on Adequacy of 2013 Response</th></tr>
<tr><td>5.2</td><td>Probability of failure estimates for culverts during mine operation and after closure are inaccurate and not applicable to the Pebble Project. Table 8-1 of the 2012 Assessment shows a low probability of failure for culverts during the operation of the mine and cites frequent inspections and regular maintenance as the reasons. Post-operation failure probability is indicated as 0.3 to 0.6, which has already been shown to not be applicable. The failure probability does not account for the use of bridges, box culverts and fish friendly culverts in place of typical culvert designs. The surveys of road culverts used as justification for the high failure rates were rarely designed for fish passage. Additionally, the report does not account for the possibility of decommissioning (removal) of some or all of the culverts post-operation.</td><td>Probability of failure estimates for culverts during and after mine operation and after closure remains unchanged in the report. However, as the 2013 Assessment reports that 35 salmonid streams would have culverts as opposed to 14 salmonid streams in the 2012 Assessment, the number of blocked culverts has increased significantly.</td><td>Geosyntec's 2012 comments remain unchanged. The failure probabilities do not account for the use of bridges, box culverts and fish friendly culverts in place of typical culvert designs. The surveys of road culverts used as justification for the high failure rates were rarely designed for fish passage. Additionally, the report does not account for the possibility of decommissioning (removal) of some or all of the culverts post-operation.</td></tr>
<tr><td>5.3</td><td>Road culvert failure modes do not consider existing state of the practice guidance. The 2012 Assessment states: "Road crossings often fail because of outfall barriers, excessive water velocity, insufficient water depth in culverts, disorienting turbulent flow patterns, lack of resting pools below culverts, or a combination of these conditions (Furniss et al. 1991)." The culvert failure modes presented in the report are comprehensive and relevant. Guidance exists for fish friendly designs that mitigate each of the failure modes, such as the Memorandum of Agreement between Alaska Department of Fish and Game and Alaska Department of Transportation and Public Facilities for the Design, Permitting, and Construction of Culverts for Fish Passage (ADFG and ADOT&PF, 2001). Each of the modes of failure cited can be addressed using modern fish passage and channel stability design principles.</td><td>The 2013 Assessment includes a new Box 10-2, Culvert Mitigation. This box describes "guidance to project designers and permitting staff to ensure that culverts are designed and installed to provide efficient fish passage and to ensure statewide consistency in Title 16 permitting of culvert related work."</td><td>Unfortunately, while Box 10-2 describes some of the relevant guidance, that is the extent of the 2013 Assessment's acknowledgement of modern fish passage and channel stability design principles. As in the 2012 Assessment, the 2013 report falls back on the following statement to justify the use of inapplicable failure statistics:

10-27 "After mine operations end, traffic would be reduced to that which is necessary to maintain any residual operations on the site, and inspections and maintenance would likely decrease. If the road was adopted by the state or local governmental entity, the frequency of inspections and quality of maintenance would likely decline to those provided for other roads. Either of these possibilities could result in a proportion of failed culverts similar to those described in the literature."

Under this scenario, it would appear that any road under government supervision is likely to have a 30% to 60% failure rate.</td></tr>
<tr><td colspan="4">SEISMIC ENVIRONMENT</td></tr>
<tr><td>6.2</td><td>The seismic analysis provided in the 2012 Assessment is biased by unsupported hypothetical faults rather than relying on the substantial geological, geophysical and seismological evidence of the seismic environment in the vicinity of the Pebble Project.</td><td>Box 4-3 of the 2012 Assessment has become Section 3.6, Seismicity, in the 2013 Assessment, with the language largely unchanged.

3-35 "Although there is no evidence that the Lake Clark Fault extends closer than 16 km to the Pebble deposit, and there is no evidence of a continuous link between the Lake Clark Fault and the northeast-trending faults at the mine site, mapping the extent of subsurface faults over long, remote distances is difficult and has a high level of uncertainty."

3-35 "Large earthquakes have return periods of hundreds to thousands of years, so there may be no recorded or anecdotal evidence of the largest earthquakes on which to base future predictions."</td><td>Geosyntec's 2012 comments remain unchanged.

The statements in the 2013 Assessment do not serve to quantify risks, but rather to raise alarm and bias the assessment. Certainly mapping faults and interpreting the geologic record is challenging. That is why the project should be designed based on appropriate design techniques and based on the best available knowledge of seismology, geology, and engineering.</td></tr>
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Geosyntec Section	2012 Geosyntec Comment	How 2013 Assessment Responds to Comment	Discussion on Adequacy of 2013 Response
6.2	The Wardrop (2011) report indicates that the TSF design will be based on the Maximum Credible Earthquake (MCE). The MCE, as defined by ADNR (2005)[11] as "the greatest earthquake that reasonably could be generated by a specific seismic source, based on seismological and geologic evidence and interpretations." As such, every potential fault that could impact a project has its own MCE, and the design must consider the most critical fault(s) for the project. The seismic analysis provided in the 2012 Assessment does not acknowledge that seismic risks will be evaluated thoroughly during the permitting process.	Box 4-6 of the 2012 Assessment has become Box 9-2, with the language largely unchanged. We note the addition of the following statement: *"Although the design specifications proposed in Ghaffari et al. (2011) exceed the minimum requirements for dams in Alaska, the deterministic dataset used is small and contains considerable uncertainties, which could lead to an underestimate of the potential seismic risk."*	Geosyntec's 2012 comments remain unchanged. The seismic analysis provided in the 2012 Assessment does not acknowledge that seismic risks will be evaluated thoroughly during the permitting process.
6.2	While the seismic discussion in the three boxes (Box 4-3, 4-5 and 4-6) in the 2012 Assessment is extensive, the references within the main text of the report are limited and very general. It appears that while the text in the boxes is intended to alarm the reader, the authors of the 2012 Assessment are not certain how to incorporate the actual seismic risk into their analyses, and hence they choose not to.	Other than moving Box 4-3 into the main body of the text (Section 3.6), the 2013 Assessment does not make any new attempts to incorporate the actual seismic risk into their analyses.	Geosyntec's 2012 comments remain unchanged. The authors of the 2013 Assessment are not certain how to incorporate the actual seismic risk into their analyses, and hence they choose not to.
WATER QUALITY			
7.1	The 2012 Assessment discounts the effectiveness of established sediment and erosion control practices for road construction and operation (Appendix G).	The 2013 Assessment includes Box 10-3, Stormwater Runoff and Sediment Mitigation. No significant modifications appear to have been made to Appendix G to address this comment.	The discussion of erosion and sediment control measures in Box 10-3 (pg. 10-33 and 10-34) partially addresses Geosyntec's 2012 comment. However, there is no discussion on how these control practices can impact the exposure and risk characterization for road construction and operation.
7.2	The 2012 Assessment has not considered mitigation strategies for addressing concerns over road salts for dust & ice control (pg. 5-62).	Revised sections of the 2013 Assessment, including Stormwater Runoff (pg. 10-29) and Dust (pg. 10-35), provide some expanded discussion on this topic. Discussion of mitigation strategies is limited to Box 10-3 (pg. 10-33 and 10-34).	The discussion of erosion and sediment control measures in Box 10-3 (pg. 10-33 and 10-34) partially addresses Geosyntec's 2012 comment. However, there is no discussion on how these control practices can impact the exposure and risk characterization for road construction and operation.
7.3	The 2012 Assessment has not considered mitigation strategies for addressing concerns over sediment contribution and effects (pg. 5-62)	Revised sections of the 2013 Assessment, including Stormwater Runoff (pg. 10-29), Fine Sediment (pg. 10-32) and Dust (pg. 10-35), provide some expanded discussion on this topic. Discussion of mitigation strategies is limited to Box 10-3 (pg. 10-33 and 10-34).	The discussion of erosion and sediment control measures in Box 10-3 (pg. 10-33 and 10-34) partially addresses Geosyntec's 2012 comment. However, there is no discussion on how these control practices can impact the exposure and risk characterization for road construction and operation.
7.5	The 2012 Assessment has not considered the role of mine reclamation to mitigate habitat loss during the post-closure period. The report does not appear to recognize that there is an opportunity to mitigate habitat lost in the mining process through reclamation design and implementation. When addressed early in planning and design, there are elements of mine reclamation that can be engineered to reduce the short and long-term impacts of mining operations. Working within operational constraints, standard reclamation activities such as the containment, placement, and stabilization of fill can be modified in consideration of final re-vegetation, habitat and land use considerations	The 2013 Assessment does not include discussion of mine reclamation for mitigation of habitat loss during post-closure.	Geosyntec's 2012 comments remain unchanged.

[11] ADNR (Alaska Department of Natural Resources). 2005. *Guidelines for Cooperation with the Alaska Dam Safety Program*. Dam Safety and Construction Unit, Water Resources Section, Division of Mining, Land, and Waters. 230 pp.