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United States Army Corps of Engineers – Alaska District
Anchorage Field Office, Regulatory Division (1145) CEPOA-RD
1600 A Street, Suite 110
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Subject: Pebble Mine Project Economics

Dear Mr. McCoy,

I write to express my professional opinion that the mine plan being evaluated by the Pebble Mine Environmental Impact Statement (EIS) process is almost certainly not economically feasible. I come to this conclusion based upon the only publicly available preliminary economic assessment performed on the Pebble project in 2011 as modified to account for the significantly lower grades, lesser ore production and likely higher initial capital costs of the new project detailed in the December 2018 Draft EIS (DEIS) Project Description. The assumed EIS mine plan produces about half as much metal for sale over its life than the smallest mine plan assumed in the 2011 economic evaluation. Based upon the economic assumptions made in the 2011 assessment, the EIS mine plan will make roughly 15 billion dollars less profit from the sale of concentrate than the smallest 2011 mine scenario and is likely to have a strongly negative net present value (NPV).

While I am aware of the Pebble Partnership's reluctance to share any capital cost information, the technical rigor of the EIS process may be compromised if no cost data are available to help select the "least environmentally damaging practicable alternative." To help ensure the integrity of the EIS process, and in fairness to local communities, the State of Alaska and to shareholders, I believe the Pebble Partnership is obligated to publicly release a new preliminary economic assessment for the proposed smaller and lower-grade mine that the Army Corps of Engineers is currently reviewing.

Professional Background

I am an environmental scientist and manager with over thirty years of experience in the mining and consulting industries. During my 23 years with the global mining company Rio Tinto I participated in and contributed to more than twenty financial and technical assessments of new major capital projects, divestments and potential acquisitions. I have performed environmental and permitting work at over fifty mines, projects and operations. This included over seven years as Head of Environment for Rio Tinto's Copper, Copper & Diamonds and Copper & Coal Product Groups. I have published numerous papers on mine environmental

performance and management in peer reviewed scientific journals, conference proceedings and books. I am intimately aware of the environmental challenges, issues and costs posed by the responsible development, operation and closure of large copper mines.

The 25-Year Mine Case Evaluated in 2011

In 2011 Northern Dynasty Minerals Limited commissioned Wardrop to complete a Preliminary Assessment of the Pebble Project. The Northern Dynasty website directs interested parties to a web location where this document can be viewed, although the reader is cautioned that the 2011 study "while instructive as to the size and scale of project that the Pebble resource might support, it is now outdated and cannot be relied upon." The preliminary assessment performed financial evaluations on 25-, 45- and 78-year mine scenarios. However, the discussion below is focused on the 25-year mine scenario as this most closely resembles the 20-year mine life proposed in the DEIS Project Description (Appendix N). The 25-year mine case was predicted to have an up-front capital cost of 4.7 billion dollars required to process a total of 1990 million tons of ore. The NPV of the project was predicted to be 3.8 billion (pretax) in 2011 dollars assuming a seven percent annual discount rate.

Because future income and costs are discounted, NPV estimates are highly sensitive to costs and revenue in the early years of the economic assessment. The project value is particularly affected by the construction capital costs which, by necessity, must be incurred before any ore production and concentrate sales can occur. Pebble's assumed construction costs of $4.7 billion are anomalously low compared to other large copper mines that have been studied or built over the past five to ten years. For example, over six billion dollars was spent on construction of the Oyu Tolgoi copper mine in Mongolia which went into production in 2013 after four years of construction. The Las Bambas copper mine in Peru spent more than seven billion dollars on construction before going into production in 2016. The Cobre Panama copper mine is currently in construction but its capital cost estimate from 2012 is also about six billion dollars. All of these copper mines are open pits with conventional concentrators similar to what is proposed at Pebble. The nearby Donlin gold mine in Alaska is also estimated to have a construction cost of seven billion based for the most part upon a 2011 economic evaluation. Part of the apparent discrepancy in capital cost can be attributed to the removal of $1.3 billion in capital from the 2011 Wardrop construction cost estimate because "it has been assumed in the financial evaluation that the Pebble Partnership will enter into strategic partnerships as needed to develop, finance and operate a number of infrastructure assets – including the transportation corridor (port and road) and the power plant." However, it is unclear who would partner with the Pebble project in order to provide this extra capital. As such, this assumption is considered speculative. Adding this $1.3 billion back into the capital cost estimate for the Pebble 25-year mine case brings the total construction cost up to six billion dollars which is a little more in line with these other projects.

However, actual construction costs could be significantly greater than six billion. In every analogue case cited above, 1) the design ore throughput is less than what was proposed in the

2011 study at Pebble, 2) the analogues in many cases are located closer to existing infrastructure and, perhaps most importantly, 3) none of them is located in as sensitive an environmental setting as Pebble. In 2013 Anglo-American withdrew from the Pebble Partnership after expending roughly $500 million on the project. According to a document prepared by Kerrisdale Capital (2017), which reportedly interviewed several of the Anglo-American personnel involved in the Pebble project, the actual capital cost for construction of Pebble could exceed ten billion dollars. If true this would have made the NPV of the 25-year mine case strongly negative. The withdrawal of all other large-scale and experienced mining investors (Mitsubishi in 2011, Rio Tinto in 2014 and First Quantum in 2018) may also have been due, in part, to skepticism about the financial viability of the projects evaluated in 2011 as well as the substantial permitting and environmental risks posed by the project.

Comparison between the 2011 and the 2018 EIS Mine Plans

Given the lower average grades, smaller production totals and likely equal or greater construction capital required for the 2018 EIS mine plan, it is almost certain to be less profitable than the 25-year mine plan evaluated by Wardrop in 2011. Some key differences in project ore feed and contained metal are contained in the table below.

	EIS 20-Year Mine	Wardrop 25-Year Mine	EIS/Wardrop
Copper Grade	0.29%	0.38%	76%
Copper Total Production	7.4 billion pounds	15 billion pounds	49%
Gold Grade	0.27 grams/ton	0.34 grams/ton	79%
Gold Total Production	12.1 million ounces	23 million ounces	53%
Molybdenum Grade	154 ppm	182 ppm	85%
Moly Total Production	398 million pounds	725 million pounds	55%

Almost every mining project attempts to target the highest-grade portions of the ore body early in the mine life in order to pay for the very large up-front capital costs associated with mine construction as soon as possible. However, due to the geometry of the Pebble ore body, and given the absolute need to lower the large environmental impacts and risks associated with mining in the sensitive Pebble setting, the EIS mine plan actually targets relatively low-grade portions of the ore body and only mines about ten percent of the total estimated resource. In sum the value per ton of ore mined by the 20-year EIS plan is about 21% lower than the average ore mined in the 25-year plan. The total mass of all copper, gold and molybdenum produced is almost half. This has a profound negative impact on the likely economics of the mine being evaluated by the EIS. A comparison of the profits generated by concentrate sales from the two projects can be made using the life of mine average net smelter return per ton of ore milled calculated in 2011 minus the average total operating costs per ton of ore milled. For the 25-year mine plan this equates to: ($27.45/ton – $11.16/ton)*1990 million tons of ore = $32 billion. For the 20-year mine plan this equates to: (0.79*$27.45/ton – [$ 11.16/ton – 2.30/ton])*1300 million tons of ore = $17 Billion[1]. Thus, the mine currently being evaluated in

the EIS process makes $15 billion less profit from concentrate sales. When this difference is apportioned by year and a discount rate of seven percent per year is applied, this equates to a five billion dollar reduction in NPV between the 25-year plan evaluated in 2011 and the 20-year EIS case. It is certainly acknowledged that these are approximate, back-of-the-envelope calculations but the strategic implications for overall project economics are significant and will be extremely difficult to offset.

The 25-year mine plan also appears to have significantly underestimated operational and closure costs associated with perpetual water treatment. On average the mine area receives more than 50 inches per year of precipitation. This is more than four times the average annual evaporation. The ore body and much of the associated country rock is also prone to acid rock drainage. Given these conditions it is almost certain that any open pit mine will create perpetual water management and treatment liabilities. According to the December 2018 Project Description, the mine will have an annual average surplus of 29 cfs (13,000 gallons per minute) for the maximum mine footprint. This will likely increase to almost 20,000 gpm in the early years of closure when long-term water storage in the tailings pore space is no longer available, before major reclamation works are completed and during the initial stages of tailings drain-down. Even after the potentially acid forming tailings and waste rock are submerged in the fully developed pit lake and the tailings have been capped with an infiltration-limiting cover, a water management liability of roughly 3000 gpm or more will likely persist in perpetuity[2]. DEIS water quality predictions confirm that most of this water will need to be treated to meet the extremely strict water quality criteria needed to protect salmon and other aquatic species.

By necessity, Pebble has proposed a very costly and complex multistage water treatment process which to my knowledge has not been attempted for such high flows anywhere else in the world. Applying a treatment cost of $5.80/1000 gallons[3] to these flows predicts that during operation up to about $40 million/year may be required for water treatment, that early in closure this could raise to $55 million/year and then decline to roughly $8 million/year in perpetuity. However, the 2011 Wardrop study only assumed a water treatment cost of 6.3 million per year during operation and was largely silent about any closure water treatment liabilities. Applying a seven percent discount rate to these values during operation and to the first hundred years after closure yields an NPV cost which is approximately $400 million higher for the life of mine project than assumed in 2011.

Financial and Permitting Implications

As shown in the table below, when the higher construction costs; higher operational and closure expenditures for water treatment; and much lower revenue from concentrate sales are factored into the Wardrop study's 25-year mine plan economic evaluation, the 20-year mine plan being considered by the Pebble EIS has a negative NPV of approximately three billion dollars. This should only be considered a conceptual level approximation of the project's actual NPV. While a new rigorous economic evaluation may make the NPV less or more negative, I

believe it is very unlikely to make the project have a positive rate of return on what is likely to be an extremely large and risky capital investment.

	NPV
Estimated NPV of the 2011 Wardrop 25-Year Mine Plan[4]	+$3.8 Billion
Capital for Access Corridor and Power Plant added back into construction cost	-$1.3 Billion
Lost revenues from decreased concentrate sales	-$5 Billion
Refined perpetual water treatment costs	-$0.4 Billion
Conceptual NPV of the EIS 20-Year Mine Plan	**-$3 Billion**

If the base case mine plan assumed for the EIS is not economic, then the entire permitting process risks being compromised because the impacts and risks being evaluated are much smaller than those required for a full-scale economically viable project. In other words, the EIS is not evaluating the "least environmentally damaging practicable alternative." This situation would also place prospective developers in a difficult situation because in order to create a profitable operation they would either need to 1) immediately begin a new EIS for a larger economically viable mine plan or 2) knowingly permit, fund and build an uneconomic mine in the hopes that a later EIS and permitting process would allow a larger, economically viable operation. In either case, a larger open pit mine would almost certainly take on many of the characteristics of the 25-year case assessed by Wardrop in 2011 and the Pebble 2.0 scenario evaluated by the USEPA in 2014 with billions of tons of additional waste rock production, much larger tailings dams and a step-change increase in disturbed footprint.

At a minimum relative capital costs for different development and design options need to be evaluated by the Army Corps of Engineers so a meaningful options analysis can be conducted on practicable alternatives. To help ensure the integrity of the EIS process and in fairness to local communities, the State of Alaska and to shareholders, I believe the Pebble Partnership is obligated to publicly release a new preliminary economic assessment for the proposed smaller and lower-grade mine that the Army Corps of Engineers is currently reviewing.

Sincerely,

Richard K. Borden

Owner Midgard Environmental Services LLC
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Footnotes:

[1] Given the assumed long-term metals prices, net smelter return and net operating cost values are from a 2011 study (Wardrop, Preliminary Assessment of the Pebble Project, Southwest Alaska, February 17, 2011) all cost are in 2011 dollars and have not been escalated to 2019 dollars. The net smelter return calculated for the 25-year mine plan in 2011 is multiplied by 0.79 to account for the 21% lower average ore grades (in copper equivalents) of the proposed EIS mine. Similarly, the total operating cost per ton of ore milled is reduced by $2.30 to account for the negligible waste rock stripping of the EIS case compared to a stripping ratio of 1.5 assumed in the 25-year mine plan ([1.5/2.5]*[Wardrop net mining cost per ton of ore]).

[2] In order to prevent groundwater outflow from the pit, the pit lake will need to be maintained at a lower level than the surrounding groundwater surface in perpetuity. The water removed from the pit lake will require treatment before release. This is conservatively assumed to be 1300 gpm based solely on the ultimate pit footprint, annual average precipitation and annual evaporation. In this extremely wet climatic setting a good infiltration-limiting soil cover on the bulk tailings storage facility is likely to allow infiltration of approximately 20% of incident rainfall based on historic cover performance across the world. Based on the bulk tailings footprint, annual rainfall and this rate of infiltration, seepage of about 1400 gpm is likely to persist in perpetuity even after operational drain down is complete.

[3] In 2013 the Canadian Mine Environmental Neutral Drainage program completed a study of more than 100 mine water treatment plants which were predominantly located in the USA and Canada. The average water treatment plant operational cost in the study was $1.54 per 1000 liters ($5.82 per 1000 gallons). The US and Canadian dollar were at near parity for 2013 when the study was completed. In reality the Pebble water treatment strategy is much more complex than the average treatment plant in the review and so its costs per 1000 gallons are likely to be higher. (Review of Mine Drainage Treatment and Sludge Management Operations, MEND Report 3.43.1, 2013).

[4] Given the lack of any new published capital cost data for the EIS mine plan, this assumes construction capital costs are roughly the same for the 25-year and 20-year projects. There are likely to be some incremental capital cost savings for the 20-year mine because ore throughput is about 20% lower, so construction costs for the concentrator and associated support infrastructure will also likely be lower. Initial truck and shovel fleets are likely to be less costly for the 20-year mine plan because of the much lower waste rock stripping ratios. The length of the access road corridor is also less in the new mine plan. However, these cost savings will almost certainly be offset by capital cost increases associated with new or redesigned infrastructure such as: 1) a new complex stand-alone pyrite tailings management system covering 1.7 square miles, 2) much larger and more costly water management infrastructure than envisioned in 2011; 3) construction of two ferry terminals on Lake Iliamna and the purchase of large ice-breaking ferry; and 4) tailings embankment construction with a more stable embankment outer slope of 2.6:1 (horizontal to vertical) versus the 2:1 slope assumed in

2011 which will likely require significantly more material quarrying and movement. Similarly, there is a lack of any information on sustaining capital for the 20-year plan, so it is assumed that sustaining capital requirements are the same for the first twenty years of the two plans. Although the 25-year mine plan has additional sustaining capital requirements for years 21 to 25, at a seven percent discount rate the value of any late capital expenditures is reduced by roughly 80% in the NPV calculations and has a negligible impact on overall project economics.