

COMPARISON of the PEBBLE MINE with OTHER ALASKA LARGE HARD ROCK MINES

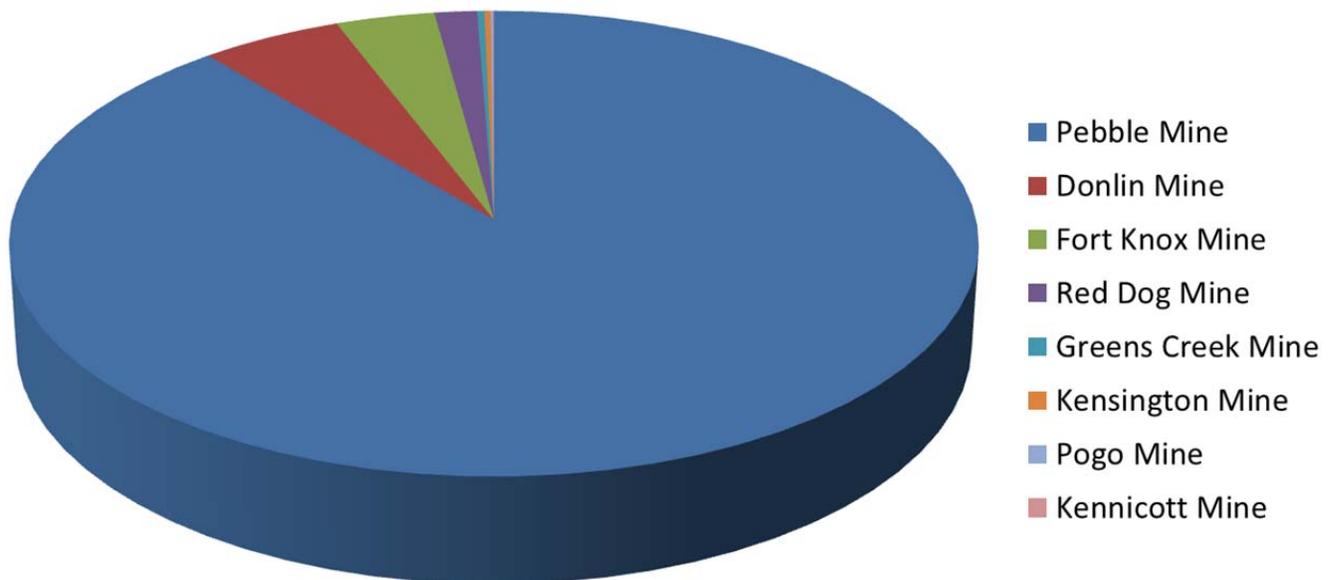
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Summary

If permitted, the Pebble mine will be North America's, and one of the world's largest mines. It has been suggested that in spite of its size the Pebble mine is comparable to other Alaska mining projects.

The amount of ore mined and the area that would be disturbed by development at the Pebble mine is on a scale entirely of its own in Alaska, and even enormous on a global scale. Size alone does not determine impacts, but based on other factors such as acid producing potential, easy movement of water away from the mine, a world class fishery, wet climate regime, etc., the mine's potential impacts could be significant and irreparable.

Ore in Alaska Hard Rock Mines



Several of Alaska's large mines have potentially acid producing ore, but none are truly comparable with the size of the proposed Pebble mine. The Pebble Mine is unique compared to Alaska's other large, hard rock mines when looking at characteristics such as size, geochemistry, geomorphology, fisheries, and hydrology. When viewed through the aggregate of these factors, the Pebble mine is distinctly different from any other present or past hard rock mine in Alaska.

More important is Pebble's massive potential to impact the pristine lands with industrial development. The Bristol Bay watershed is unique in Alaska because it comprises Alaska's, and one of the world's, greatest salmon fisheries. It supports cultural, subsistence, commercial, recreational, economic, and environmental values that are unparalleled.

<u>Alaska Mine</u>	<u>Mineral Resource (Million Tonnes)</u>	<u>Type / Ore Mineralization</u>
Pebble Mine ¹	10,780	Open Pit & Underground - Copper/Gold/Molybdenum
Donlin Mine ²	634	Open Pit - Gold
Fort Knox Mine ³	442	Open Pit - Gold
Red Dog Mine ⁴	190	Open Pit - Zinc/Lead
Greens Creek Mine ⁵	32	Underground - Silver/Zinc/Lead/Gold
Kensington Mine ⁶	27	Underground - Gold
Pogo Mine ⁷	10	Underground - Gold
Kennecott Mine ⁸	5	Underground - Copper

<u>Alaska Mine</u>	<u>Precipitation</u>	<u>Terrain</u>
Pebble Mine	average 36 inches per year, most as rain	interior Alaska, low mountains
Donlin Mine	average 15 to 30 inches per year	interior Alaska, low mountains
Fort Knox Mine	approximately 20 inches per year	interior Alaska, low mountains
Red Dog Mine	approximately 18.4 inches per year	interior Alaska, low mountains
Greens Creek Mine	approximately 40-50 inches per year	coastal Alaska, steep mountains
Kensington Mine	approximately 63 to 81 inches annually	coastal Alaska, steep mountains
Pogo Mine	less than 20 inches per year	interior Alaska, low mountains

The Pebble Mine and its host environment are not comparable with other Alaska mines or their environments. That Pebble poses a greater threat to the environment or fishery does not mean that the practices at other, less threatening mines are not problematic. It simply implies that Pebble poses greater qualitative and quantitative threats than any other Alaska mine to fisheries, the environment, and cultural and economic resources.

This report is divided into two main sections. The first, PEBBLE MINE CHARACTERISTICS, looks at particular characteristics that are important in reviewing the Pebble Mine. The second section, PEBBLE MINE COMPARED TO OTHER ALASKA MINES, discusses large Alaska mines with key common and distinguishing features.

¹ Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, February 17, 2011.

² Donlin Creek Gold Project, Alaska, USA, NI 43-101 Technical Report, Nova Gold Resources Inc., April 1, 2009, p. 1-1.

³ Technical Report for the Fort Knox Mine, Kinross Gold Corporation. March 31, 2008

⁴ Environmental Information Document for the Aqqaluk Extension, SRK Consulting, Apr07, Tables 2.1.2, 2.1.3.

⁵ Probable, Indicated, and Inferred Resources as of 31Dec10 from:

http://www.hecla-mining.com/operations/operations_greencreek_reservesresources.php;

Production as of Sep11 from: Investor Fact Sheet, Hecla Mining Company, January 2012, downloaded from:

http://www.hecla-mining.com/investors/investors_investor_package.php

⁶ Maximum buildout based on 1992 EIS.

⁷ Based on amount of tailings produced, Final Environmental Impact Statement Pogo Gold Mine Project, USEPA Region 10, September 2003, p. 2-15.

⁸ Winkler, G, A Geologic Guide to Wrangell-Saint Elias National Park and Preserve, Alaska, U.S. Geological Survey Professional Paper 1616, 2000.

PEBBLE MINE CHARACTERISTICS

The proposed Pebble Mine is a low grade, high-volume copper mine located on state land in the Bristol Bay Region of southwest Alaska. It lies at a confluence of rivers that are critical to the salmon fisheries of Bristol Bay; the nearest communities are Nondalton and Iliamna/Newhalen.

The Pebble Mine's ore contains only scattered specks and tiny veins of copper mineralization: approximately 0.34% copper, 0.023% molybdenum, and 0.01 ounces of gold per ton.⁹ Extracting one pound of Pebble's copper requires pulverizing and chemically processing 294 pounds of ore. Pebble is principally a copper deposit, with copper representing approximately 95 percent of recoverable metal by volume and 60 percent by value. The mine also seeks to dig an open pit and underground mine to remove copper, molybdenum, and gold.¹⁰

Geology

Pebble's near-surface geology has thick layers of highly permeable glacial gravels. The water table lies near the surface resulting in seeps and springs that recharge both surface and substrate. Most mines have leaks and spills, both small and large, but at Pebble any leak has a particularly high potential to cause contamination because of the potential to migrate offsite.

Deposits of glacial permeable sediments are largely unconfined and mine spills or leaks could be difficult to contain. Pebble's highly permeable glacial gravels will present difficult design and management problems for both waste contaminant discharge and spill containment.

Mine Type

Pebble will employ both open pit mining and underground block caving during its long lifetime of approximately 100 years. The mining rate for ore at Pebble is projected to be between 100,000 and 200,000 tons of ore per day. The stripping ratio of waste:ore at Pebble 12, using the 45-year Reference Case, is projected to be 2.13:1.¹¹ This means that waste rock, much of which will contain subeconomic amounts of sulfide mineralization, will be generated/mined at a rate of 213,000 to 426,000 tons per day. The mining rate could potentially reach as much as 1,000,000 tons/day (ore and waste).¹² Open pit mines produce far more waste rock than underground mines.

According to the most recent technical report, Pebble's 45-year pit would be approximately 2500 feet deep and 13,000 feet long, and the 78-year pit would be approximately 4000 feet deep and 17,000 feet long.¹³ The largest of the tailings dams at Pebble will be approximately 700 feet in height.¹⁴

Underground block caving, a bulk mining method, while producing far less waste rock than open pit mining, has the disadvantage of causing subsidence at the surface due to the removal of large amounts of ore. Once the surface is ruptured, water can percolate down through the rubble-rock material remaining in the mine. Contaminants in the rock related to the decomposition of sulfide minerals, heavy metals (e.g. copper, zinc, lead, cadmium, or mercury) or neutral drainage metalloids (e.g. arsenic, selenium, thallium or antimony) can migrate with groundwater and eventually reach surface waters.

⁹ Calculated from resource information given in Table 21.1, "Technical Report on the 2009 Program and Update on Mineral Resources and Metallurgy Pebble Copper-Gold- Molybdenum Project Iliamna Lake Area Southwestern Alaska, U.S.A.," J. David Gaunt, et al., for Northern Dynasty Minerals Ltd, March 17, 2010.

¹⁰ The Pebble Partnership, http://www.pebblepartnership.com/project/faqs#mineral_breakdown, Internet website FAQs.

¹¹ Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, 17Feb11, p.

¹² Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, 17Feb11, p. 39 (using the 45-year Reference Case)

¹³ Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, 17Feb11, p. 37.

¹⁴ Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, 17Feb11, p. 52.

Geochemistry

Most of the world's copper comes from porphyry deposits. In this regard, the Pebble mine is not unique. Porphyry mines have a poor record of environmental degradation because of their low buffering capacity and tendency to leach contaminating metals into groundwater from waste rock, tailings, and from pit and underground workings.

Most porphyry deposits/mines are large and low grade, leading to the production of large quantities of waste rock and tailings. Porphyry deposits are of volcanic origin. The metal mineralization is in the form of metal sulfides, but these deposits typically contain few acid-neutralizing minerals. In dry environments the contaminants associated with porphyry deposits are not as likely to form and/or escape from the mine site. In wet environments, however, the environmental risks at porphyry mines are higher.

The geochemistry at the Pebble mine indicates that much of the mined rock will be potentially acid generating (PAG), and that the primary metal contaminant will be copper.¹⁵ Geomorphology suggests that leaked contaminants will be difficult to contain.¹⁶ Pebble's relatively wet environment increases the likelihood that these contaminants will become mobile. There could be a significant horizontal and vertical distribution of contaminants, and the nature of the contaminants, most significantly copper which is especially toxic to salmonids, is of concern.

At Pebble, sulfur mineralization is typically between 1 and 5 percent, with maximum concentrations near 9 percent sulfur.¹⁷ There are significant amounts of iron (the most common sulfide mineral), with some antimony, arsenic, selenium, and zinc. These metals are not present in large enough quantities to justify economic recovery, so they will remain in the waste. In addition, mine rock that does not contain enough economic mineralization, but still has elevated levels of sulfide minerals, will become waste rock. This PAG waste rock must be identified and segregated from the non-PAG waste rock. If this material were to be erroneously placed in the normal waste rock piles, oxygen and water would be readily available, and metals could leach from the waste.

A significant portion of Pebble's tailings and waste rock will be PAG material, and will require special storage and monitoring. Preliminary geochemical information indicates that some of the PAG material at Pebble might generate acid even under water.¹⁸ Mitigation techniques employed at porphyry mines have been notoriously ineffective to slow acid production and to prevent it from leaving the minesite. Pebble's extremely large size means that any acid rock drainage (ARD) problem could be difficult to control. Pebble's many billions of tons of waste rock and tailings, and the abandoned pit and underground mines pose a formidable source of ARD, particularly with its climatic and geomorphologic environment.

¹⁵ Pebble Project Environmental Baseline Document, 2004 through 2008 (with updates in 2010), Chapter 11 Geochemical Characterization, Bristol Bay Drainages, prepared by: SRK Consulting Inc., Section 11.7.1.10 Conclusions.

¹⁶ Hamilton, T.D. and R.F. Klieforth, Report of Investigations 2009-4, Surficial Geologic Map of Parts of the Iliamna D-6 and D-7 Quadrangles, Pebble Project Area, Southwest Alaska, Published by State of Alaska, Department of Natural Resources, Division of Geologic & Geophysical Surveys, 2010

¹⁷ "Draft Environmental Baseline Studies 2004 Progress Reports, Chapter 8, Geochemical Characterization & Metals Leaching/Acid Rock Drainage," Northern Dynasty Mines, Inc., June 2005, p. 8-10.

¹⁸ "Status of Kinetic Test Program and Proposed Modifications, Pebble Project, DRAFT 2", Claire Linklater and Stephen Day, SRK, September 14, 2009.

Long Term Waste Storage

The storage of billions of tons of waste at Pebble poses two significant issues.

First, the science of predicting the contamination from, and impacts of, the mine waste and the abandoned open pit and underground workings, is not well developed.¹⁹ Predictions of the onset (timing) and amount of contaminants from mines, and of the mitigation techniques that will prevent the offsite migration of these contaminants, have not met with much success, especially for the type of deposit at Pebble (sulfide minerals with surface and groundwater in the immediate vicinity).²⁰ Most problems with contaminants from acid mine drainage don't become apparent until after mine closure.

Second, the Pebble mine will need to construct very large dams to contain the billions of tons of tailings produced by processing the ore. Over 99% of the material mined (ore and waste rock) will remain on the mine site. The tailings dams will be among the largest in the world, and must withstand climatological and seismic events in perpetuity. Floods and earthquakes are the two most common causes of tailings dam failures,²¹ which occur at a worldwide rate of roughly one failure every 8 months.²² Although the probability of such a catastrophic failure is low, the consequences, should it occur, are very high.

Reclamation bonds held by regulatory agencies do not cover cleanup costs for mine accidents. Cleanup costs are often paid by taxpayers. If the tailings are not cleaned up, the long term environmental and social costs would then be borne by the public. A tailings dam failure at the Pebble mine could spread tailings all the way from the mine site to Bristol Bay itself.²³

Fisheries

The Bristol Bay Watershed supports three important salmon fisheries – the world's greatest commercial salmon fishery, a significant non-resident recreational fishery, and an important subsistence fishing for Alaska Natives that is critical from both a cultural and economic perspective.

The Pebble project seeks to mine on top of the world's largest wild sockeye salmon fishery. No other Alaska mine site's fishery approaches the quantity of fish or the number of people culturally or economically dependent on that fishery.

The commercial fishing industry value is unparalleled; estimated to be worth \$350 million per year.²⁴

Recreational fishing (guiding and tourism) draws over 15,000 non-resident anglers to travel to Bristol Bay for blue-ribbon waters supporting rainbow trout, five salmon species, char, and Dolly Varden.²⁵

Subsistence fishing is important from both a cultural and economic perspective in the entire Bristol Bay region. Alaska Natives feed their families by fishing the Bristol Bay watershed. Sixty-five percent of the

¹⁹ Predicting Water Quality at Hardrock Mines, Methods and Models, Uncertainties, and State-of-the-Art, Ann S. Maest, James R. Kuipers, Constance L. Travers, and David A. Atkins, 2005

²⁰ Comparison of Predicted and Actual Water Quality at Hardrock Mines, Kuipers et. al., 2006.

²¹ Tailings Dams, Risk of Dangerous Occurrences, Lessons Learnt from Practical Experiences, Bulletin 121, International Commission on Large Dams, 2001.

²² Long Term Risks of Tailings Dam Failure, Chambers and Higman, 2011.

²³ An Assessment of Ecological Risk to Wild Salmon Systems from Large-scale Mining in the Nushagak and Kvichak Watersheds of the Bristol Bay Basin, Ecology & Environment, October 2010.

²⁴ Commercial Fisherman for Bristol Bay. Internet Website: <http://fishermenforbristolbay.org/>.

²⁵ American Rivers' Bristol Bay Fact Sheet. <http://act.americanrivers.org/MER/factsheets/factsheet-2.pdf>.

borough's residents are Alaska Natives, and many/most continue to practice traditional subsistence fishing activities.²⁶

The ecologic value of the fishery means that many other species depend on Bristol Bay's fishery for their survival.

Road

The Pebble mine is located in a remote area, and would require construction of an industrial road roughly 104 miles long to supply construction and operating materials. The road and accompanying stream crossings, dust (the road would not be paved), secondary roads, and multiple stream crossings would lead to major changes to the area around and leading to the mine. The road and associated infrastructure needs at Pebble could cause socioeconomic and environmental impacts due to the present undeveloped nature of the Lake Iliamna area, and the comparatively large size of the Pebble mine.

PEBBLE MINE COMPARED TO OTHER ALASKA MINES

Red Dog

Red Dog is one of the largest zinc mines in the world. It lies in the foothills of the DeLong Mountains in the Brooks Range, approximately 90 miles north of Kotzebue and 52 miles from the Chukchi Sea. The land encompassing the mine is owned by the NANA Regional Corporation.

Red Dog's low, rolling mountains are similar to those at Pebble. However, Red Dog's mountains are mainly tundra-covered, and permafrost lies only a few feet below the surface. Like Pebble, Red Dog is located high in the drainage, and several small streams feed into the main stream system draining the area.

The Middle Fork of Red Dog Creek cuts through the ore body, and the water quality of this stream was significantly degraded before any mining started due to natural ARD from the ore body. There was no previous development on the site.

The South Fork of Red Dog Creek has been converted into a tailings impoundment, and the North Fork of Red Dog Creek is relatively pristine. Red Dog Creek flows into Ikalukrok Creek, which in turn flows into the Wuluk River, a major salmonid spawning stream in the area. The value of the Wuluk fisheries is very low compared to that of Bristol Bay.

The Red Dog deposit contains very high grade ore with proportionally high levels of sulfide minerals. The waste rock and tailings have high acid producing potential. Some of the waste rock has potential future value as low grade ore.

The deposits at Red Dog contain approximately 190 million tons of ore,²⁷ compared with Pebble's 10.78 billion tons²⁸ (more than 50 times more).

The permafrost underlying the site has a thickness from less than 100 feet to over 660 feet.²⁹ The permafrost strongly controls Red Dog's groundwater - there is no regional scale shallow groundwater flow system in upland areas.³⁰ Shallow flow only occurs in local areas for short periods of time.³¹ This is

²⁶ Tim Woody. The Wilderness Society, September 2011. Pebble Mine makes ballot; Will Alaskans save Bristol Bay from open-pit mine? <http://wilderness.org/content/pebble-mine-makes-ballot-will-alaskans-save-bristol-bay-open-pit-mine>.

²⁷ Environmental Information Document for the Aqaluk Extension, SRK Consulting, Apr07, Tables 2.1.2, 2.1.3.

²⁸ The Pebble Partnership, Internet website FAQs <http://www.pebblepartnership.com/project/faqs>.

²⁹ Red Dog Mine Extension – Aqaluk Project Supplemental Environmental Impact Statement, Tetra Tech Inc., Oct09, p. 3-74

³⁰ Red Dog Mine Extension – Aqaluk Project Supplemental Environmental Impact Statement, Tetra Tech Inc., Oct09, Section 3.6 Water Resources – Groundwater

³¹ Ibid.

almost exactly the reverse of the groundwater situation at Pebble, where thick beds of glacial sediments provide a high-volume conduit for groundwater to move away from the mine.

The tailings dam at Red Dog is being raised to 208 feet high, and was designed to operate as a “zero-discharge” facility.³² Seepage under and around a tailings dam is typical of all dams. The pumpback rate for seepage under the Red Dog tailings dam is on the order of 0.5 billion gallons per year, equivalent to an average annual rate of 950 gpm.³³

Water treatment will be required in perpetuity at Red Dog. The State of Alaska holds a closure bond of over \$305 million, most of which is for long term water treatment.³⁴ Pebble could face a similar requirement for long term (perhaps perpetual) water treatment. Although the material at Pebble is not as potentially acid generating as that at Red Dog, there is far more of it.

The Red Dog area had historic/background contaminants related to naturally occurring acid drainage and metals contamination. Pre-mine/baseline water quality studies indicate that, prior to mining, acid rock drainage and metal leaching from natural exposures of sulfide minerals associated with the Red Dog deposits resulted in acidic pH's and elevated concentrations of aluminum, cadmium, iron, lead and zinc in the Mainstem, Middle Fork and South Fork of Red Dog Creek, and tributaries of the Middle Fork of Red Dog Creek. Aquatic organisms were adversely affected.

No such pre-mining contamination exists at Pebble – the area is essentially pristine with naturally pure water and healthy, unimpacted aquatic organisms.

Donlin

The Donlin mine is being proposed by a joint partnership between the Barrick Gold Corporation and NovaGold Resources, both Canadian companies. The Calista Corporation, an Alaskan regional native corporation, owns most of the subsurface rights, and The Kuskokwim Corporation, a village corporation, owns some of the surface rights for the mine. The Donlin mine would pay annual royalty/property payments to the native corporations.

The Donlin project is located near the Kuskokwim River about 15 miles north of the village of Crooked Creek. The Kuskokwim contains a fishery that supports both subsistence and commercial fishing, which is important because of mine's proximity to the river. However, the Kuskokwim's fishery is significantly smaller in scope, scale, use, and economic value compared to that of the Nushagak and Kvichak Rivers and the Bristol Bay fishery.

If permitted, the proposed Donlin gold mine, which would utilize two open pits, will be the largest mine in Alaska after the Pebble mine,. Donlin will process approximately 53,000 tons of ore per day, compared to Pebble's proposed 100,000 to 200,000 tons per day of ore.³⁵ The Donlin mine is projected to operate for 25 years,³⁶ while Pebble could operate for more than a century.

Donlin has potential for neutral drainage (primarily arsenic),³⁷ but the likelihood of ARD is less than at Pebble because of the presence of carbonate rocks. Mercury is present in significant quantities in the Donlin ore, and mercury release to the air is a potential issue because the Donlin ore will be subjected to

³² Red Dog Mine Extension, Aqqaluk Project, Final Supplemental Environmental Impact Statement, Oct09, p. 2-5

³³ SRK Consulting, April 2007, Project Reference Number SRK 1CT006.004. Sections 2.1 and 2.2 Environmental Information Document for the Aqqaluk Extension. p. 2-10.

³⁴ Waste Management Permit No. 0132-BA002, Red Dog Mine, Alaska Department of Environmental Conservation, 2Dec09.

³⁵ Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, 17Feb11, p. 9

³⁶ Donlin Gold Project, Alaska, NI 43-101 Technical Report on Second Updated Feasibility Study, AMEC, 18 Nov11, p. 1-19.

³⁷ Donlin Gold Project, Alaska, NI 43-101 Technical Report on Second Updated Feasibility Study, AMEC, 18 Nov11, p. 18-11

high temperature processing which will vaporize mercury.³⁸ Donlin will utilize cyanide in a vat leach process to extract gold. Pebble might also use cyanide in lesser amounts for the direct extraction of gold from a secondary (to copper) processing circuit, and perhaps as a minor constituent of floatation processing.³⁹

Fort Knox

The Fort Knox mine is located on Gilmore Dome, 25 miles northeast of city of Fairbanks, Alaska's second largest metropolitan area. It is adjacent to an existing road system, and the necessary supporting infrastructure, including housing and power, is available in Fairbanks.

Fort Knox is a medium-sized open pit mine, producing 36,000 - 50,000 tons/day of ore, and an equal amount of waste rock.⁴⁰ The open pit at Fort Knox is projected be cover approximately 0.4 square miles at mine closure. The tailings dam at Fort Knox is 366 feet in height,⁴¹ and will impound 200 million tons of tailings, and the tailings dam and pond will cover approximately 1.75 square miles.⁴²

The ore is crushed and ground, then processed using cyanide to extract gold. Part of the ore is processed using flotation, and tailings from the cyanide vat processing are pumped to a tailings pond. A heap leach pad was recently opened at the mine for processing low grade ore. The ore at Fort Knox is relatively low in sulfur with little other non-gold mineralization, and neither the tailings nor the waste rock at Fort Knox are potentially acid generating.⁴³

Greens Creek

The Greens Creek Mine is a zinc, lead, silver, and gold mine located on Admiralty Island, 18 miles southwest of Juneau. Dense forests cover the mountain slopes up to an elevation of 2500 feet, above which the vegetation is alpine. The mine and mill facilities are located over 6 miles up Greens Creek from Hawk Inlet tidewater. The maritime climate averages 60 to 70 inches of precipitation per year at the mine and waste rock site, and 45 to 55 inches per year at the tailings facility near Hawk Inlet.⁴⁴

Greens Creek is a drift and fill underground mine. Long-hole stoping is also utilized in select ore zones conducive to this mining method. Cemented tailings and production rock generated by the mining operations are used as backfill in mined-out areas to support vehicles and equipment and to provide structural ground support, allowing subsequent mining of adjacent ore. During normal production Greens Creek mines an average of approximately 2,000 tons of ore per day.⁴⁵

Greens Creek uses a flotation milling process similar to that proposed at Pebble, which would produce several concentrates to be shipped off site for final processing. Tailings not used underground are placed on the surface in a "dry-stack" tailings pile at the Tailings Disposal Facility.

Greens Creek's tailings are classified as potentially acid generating.⁴⁶ The dry-stack tailings facility is lined to prevent the escape of contaminants to groundwater. There is no present plan for lined tailings facilities at Pebble.

³⁸ Donlin Gold Project, Alaska, NI 43-101 Technical Report on Second Updated Feasibility Study, AMEC, 18 Nov11, p. 13-4

³⁹ Preliminary Assessment of the Pebble Project, Southwest Alaska, Wardrop-Northern Dynasty Mines, 17Feb11, p. 50.

⁴⁰ Technical Report for the Fort Knox Mine, Kinross Gold Corporation, March 31, 2008, p.9.

⁴¹ Fort Knox TSF & WSR Dam Failure Analysis, SRK Consulting (U.S.), Inc, Mar10, p. i.

⁴² Water Management Consultants, Inc., Fort Knox Mine Tailing Facility Closure Management Plan, June 2006, p. 8.
<http://dnr.alaska.gov/mlw/mining/largemine/fortknox/pdf/tailingclose.pdf>.

⁴³ Five-Year Environmental Audit, Fort Knox Mine, True North Mine and Twin Creek Road, Golder Associates Inc., 1Mar04

⁴⁴ Greens Creek Tailings Disposal Final Environmental Impact Statement, USDA Forest Service, Nov03, Section 3.3 – Climate

⁴⁵ Greens Creek Tailings Disposal Final Environmental Impact Statement, USDA Forest Service, Nov03, p. 1-2

⁴⁶ Greens Creek Tailings Disposal Final Environmental Impact Statement, USDA Forest Service, Nov03, p. 1-11

Kensington

The Kensington Gold Project is an underground gold mine approximately 45 miles north-northwest of Juneau. Kensington is processing 1,250 tons per day.⁴⁷ The rock at Kensington has a low potential for ARD because of the presence of carbonate.

Kensington employs underground stope mining with cemented paste tailings backfill. As a part of the Forest Service Plan of Operations, Kensington has committed to preventing surface subsidence. Surface subsidence is probable at Pebble due to the block caving mining method that will be employed.

Kensington is located near commercial, recreational, and subsistence fisheries. Kensington's relatively small size, the physical characteristics of the local topography (steep mountainous terrain with shallow aquifers), and waste storage facilities at the mine (small tailings dam) suggest that it poses a manageable level of threat to the Berners Bay and Lynn Canal fisheries.

The primary controversy at Kensington is the conversion of Slate Lake into a tailings facility. This is the first time since the passage of the Clean Water Act that a lake has been used for mine waste disposal. The regulatory change that allowed this conversion applies nationwide, and also applies to the potential disposal of mine waste in the ocean, streams and rivers.

Pogo

The Pogo mine is located on the Goodpaster River near Delta Junction, about 85 miles east-southeast of Fairbanks. Pogo is an underground mine, using drift and fill underground mining techniques with a capacity of 2,500 tons per day.⁴⁸ Tailings and waste rock are backfilled into the mined out stopes. The mine is located next to the Goodpaster River, a salmon producing river, but the local fishery is primarily recreational and subsistence-based.

Pogo is a gold mine, and uses cyanide to leach gold from a concentrate produced by floatation processing. The flotation tailings that have not come into contact with cyanide are pressure-filtered and placed into a drystack tailings facility. Tailings from the cyanide process circuit are detoxified, mixed with cement and flotation tailings, and then placed underground as cemented paste-fill.

The tailings and waste rock at Pogo contain high levels of arsenic. Selectively handled waste rock is segregated into mineralized and non-mineralized classes. Mineralized waste rock (>0.5% sulfur or 600 mg/L arsenic) is placed in the core of a lined drystack tailings facility, and non-mineralized waste rock (<0.5% sulfur and 600 mg/L arsenic) is placed in the shell of the drystack tailings facility.⁴⁹

Kennecott

The historic Kennecott mine was a world-class copper deposit. The Kennecott mine is sometimes used as an example of where copper mining and salmon can coexist, but to use Kennecott as an example of the potential development impacts of Pebble is inappropriate.⁵⁰

The Kennecott mine was a contact metamorphic skarn-type deposit, with both native copper and high grade copper sulfide mineralization. The proposed Pebble mine is a porphyry deposit with low grade ore.

⁴⁷ Response to Comments for Coeur Alaska, Inc. Kensington Gold Mine Juneau, Alaska APDES Permit No. AK0050571 Public Noticed April 25, 2011 – June 9, 2011. Page 2.

<http://dnr.alaska.gov/mlw/mining/largemine/kensington/ak0050571commentresponse.pdf>.

⁴⁸ Teck-Pogo Mine 5-Year Environmental Audit. Golder Associates Inc. July 28, 2009. # 083-81546.

<http://dnr.alaska.gov/mlw/mining/largemine/pogo/pdf/pogoaudit2009.pdf>.

⁴⁹ Teck-Pogo Mine 5-Year Environmental Audit. Golder Associates Inc. July 28, 2009. # 083-81546.

<http://dnr.alaska.gov/mlw/mining/largemine/pogo/pdf/pogoaudit2009.pdf>.

⁵⁰ Also see: Copper River and Bristol Bay: Comparison of Salmon and Mineral Resources, Woody and Chambers, Sep11.

The Kennecott mine's sulfides were associated with limestone (carbonate) mineralization. The combination of acid generating sulfides and large amounts of acid neutralizing carbonates reduced the risk of ARD. The Pebble mine deposit lacks this neutralizing carbonate. It has elevated concentrations of sulfides (1-9%)⁵¹ and would depend mainly on silicate minerals with low neutralizing capacity to counter acid production.

Kennecott had a high copper concentration, which averaged almost 13% copper over the life of the mine.⁵² Kennecott shipped much of its ore with minimal onsite processing and minimal waste. Over its lifetime approximately 5 million tons of ore were mined at Kennecott.⁵³ Because it was an underground mine the waste:ore ratio at Kennecott was significantly less than that at Pebble, or any open pit mine. But just in comparing the amount of ore produced at each mine, and ignoring the waste rock, it would take over 2000 Kennecott mines to produce the same amount of ore as projected for Pebble.

Kennecott sourced its water for mine production from a non-salmon bearing stream. The proposed Pebble mine will use large quantities of water for processing. Its 2006 permit applications for water totaled approximately 34 billion gallons per year, and water sought by Pebble directly supports salmon and other fisheries in the area of the Pebble mine.⁵⁴

Kennecott was located next to an active glacier with no salmon spawning in the immediate area, and was mined (1911-1938) by selective stope mining. Alaska Department of Fish and Game records show coho salmon currently use the Kennecott River, but no other species are documented as spawning or rearing downstream of Kennecott in the Nizina or Chitina rivers, although those waters are salmon migration corridors.⁵⁵

In sharp contrast, Pebble ore lies directly under salmon streams that drain to the Nushagak River and to Iliamna Lake/Kvichak River. Salmon use the headwaters of the Nushagak, and Kvichak Rivers during the freshwater phase of their life history. From 1956 to 2010, these two river systems produced over 678 million sockeye salmon - representing approximately 40% of total Bristol Bay sockeye production.⁵⁶ Upper Talarik Creek, originating in Pebble claims, flows about 20 miles from the Pebble ore body into Iliamna Lake, the world's largest sockeye salmon rearing lake, where millions to billions of sockeye fry from over 48 different spawning populations rear.⁵⁷

⁵¹ "Draft Environmental Baseline Studies 2004 Progress Reports, Chapter 8, Geochemical Characterization & Metals Leaching/Acid Rock Drainage," Northern Dynasty Mines, Inc., June 2005, p. 8-10.

⁵² A Geologic Guide to Wrangell-Saint Elias National Park and Preserve, USGS Professional Paper 1616, 11 Jun 99, p.92

⁵³ A Geologic Guide to Wrangell-Saint Elias National Park and Preserve, USGS Professional Paper 1616, 11 Jun 99, p.90

⁵⁴ Calculated from Surface (July 7, 2006) and Groundwater (September 21, 2006) Rights Applications submitted by Northern Dynasty Mines to the Alaska Department of Natural Resources, for the North Fork Kaktuli River, South Fork Kaktuli River, and Upper Talarik Creek.

⁵⁵ Alaska Department of Fish and Game fish distribution database: http://gis.sf.adfg.state.ak.us/AWC_IMS/viewer.htm

⁵⁶ ADFG anadromous waters catalogue for Iliamna region available at <http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=maps.display&LocationID=ILI250.PDF®ion=swt>

⁵⁷ Personal communication, Dr. Carol Ann Woody, Fisheries Research & Consulting, Anchorage, AK

Table 1 – Comparison of Primary Characteristics of Alaska Large Mines

Details about the Pebble Mine and Kennecott, Donlin, Fort Knox, Greens Creek, Kensington, Pogo, and Red Dog mines are presented in Table 1. Additionally, the following mines were considered and rejected from further analysis because they were deemed substantially different or otherwise not relevant to this report: Illinois Creek, Nixon Fork, Rock Creek, Niblack, and True North (a satellite mine of Fort Knox).

	<u>Pebble</u>	<u>Kennecott</u>	<u>Donlin</u>	<u>Fort Knox</u>
Company	Anglo American/Northern Dynasty	Kennecott Copper Corporation	Barrick/Novagold	Kinross Gold Corporation
Location	Bristol Bay; Headwaters of three watersheds leading to the Kvichak and Nushagak rivers.	Now in Wrangell-St. Elias National Park in Copper River drainage	13 miles north of the village of Crooked Creek and the Kuskokwim River	26 miles northeast of Fairbanks
Target Metal	copper, gold, molybdenum	copper, silver	gold	gold
Ore Type	Copper Porphyry/Sulfide	Massive sulfide	Gold-bearing quartz	Oxide ore body
Ore Grade	Low grade	Very high grade	Moderate grade	Low grade
Mine Life	78+ years	27 years (1911 - 1938)	22 years	20 years
Extraction Type	Open Pit & Underground Block Caving	Underground Stope Mining	Open Pits (2)	Open Pit
Total Resource	10.78 B tonnes	~ 5 M tons	634 M tons	442 M tons
Mining Rate - Ore	100,000 - 200,000 tpd	~ 100 tpd	53,500 tpd	36,000 - 50,000 tpd
Rate - Waste Rock	200,000 - 400,000 tpd	N/A	300,000 tpd	36,000 - 50,000 tpd
Total Waste Rock	16.9 B tonnes	Probably less than 1 M tons	2.1 B tons	372.5 M Tons
Processing	Flotation concentrate	Minor	Flotation + cyanide leach	Flotation + cyanide leach
Cyanide	Unknown	No	Yes	Yes
Tailings Disposal	Multiple Dams/Ponds	On Kennicott Glacier	Dam/Ponds (2)	Dam/Pond
Tailings Amount	2.5 to 10.78 billion tons	Probably less than 1 M tons	471 M tons	200 million tons
Tailings Footprint	6.6 square miles	N/A	2.1 square miles	1.75 square miles
Tailings Height	Multiple; largest 740 feet	N/A	Multiple, largest 470 feet	366 feet
Major AMD Issues	Yes	No	Yes	No
Buffering Potential	No	Yes	No	Minor
Proximity to Salmon/fisheries	On top of fishery	Close	Close	Not very close
Fisheries Values	Extremely High	Minor in rivers near mine; Low in comparison to Bristol Bay	Relatively low compared to Bristol Bay	Low compared to Bristol Bay
Power	Dedicated power plant via regional grid	N/A	Mixed diesel and natural gas generators (8% wind)	Regional grid

Table 1 – Comparison of Primary Characteristics of Alaska Large Mines

(continued)

	<u>Greens Creek</u>	<u>Kensington</u>	<u>Pogo</u>	<u>Red Dog</u>
Company	Hecla Mining Company	Coeur d’Alene Mines Corporation	Sumitomo Metal Mining Co., Ltd.	Teck Resources Ltd.
Location	18 miles SW of Juneau in Admiralty Island National Monument	45 miles NW of Juneau between Berners Bay and Lynn Canal	85 miles east-southeast of Fairbanks	82 mi north of Kotzebue and 46 mi from the Chukchi Sea; In the western Brooks Range
Target Metal	zinc, lead, silver, gold	gold	gold	zinc, lead
Ore Type	Massive sulfide	Gold-bearing quartz	Gold-bearing quartz	Massive sulfide
Ore Grade	High grade	Moderate grade	Moderate grade	High grade
Mine Life	35-50 years	10 years	11 years	42 years (1989-2031)
Extraction Type	Underground stope mining	Underground Stope Mining	Underground Stope Mining	Open Pits (2)
Total Resource	32 M tons	27 M tons	10 M tons	190 M tons
Mining Rate - Ore	1,680 tpd	1,250 tpd	2,500 tpd	8300 -9100 tpd
Rate - Waste Rock	200 - 250 tpd	400 - 600 tpd	475 tpd	12,600 tpd
Total Waste Rock	~ 2 M tons	1.6 M tons	1.9 M tons	157 million tons
Processing	Flotation concentrate	Flotation concentrate	Flotation + cyanide leach	Flotation concentrate
Cyanide	Yes - small amount	No	Yes	Yes - small amount
Tailings Disposal	Dry Tailings	Dry Tailings	Dry Tailings	Dam/Pond
Tailings Amount	~ 15 M Tons		5.4 M tons	100 M tons
Tailings Footprint	62 acres	60 acre	108 acres	747 acres
Tailings Height	dry tailings pile	Lake disposal	dry tailings pile	208 feet
Major AMD Issues	Yes	No	No	Yes
Buffering Potential	No	Yes	Yes	No
Proximity to Salmon/fisheries	Close	Close	Close	Close
Fisheries Values	Moderate compared to Bristol Bay	Moderate compared to Bristol Bay	Moderate compared to Bristol Bay	Low compared to Bristol Bay
Power	Regional grid and diesel	Diesel generators	Regional grid via 50-mile line	Diesel generators