The Costs of Climate Change on Pebble Mine

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Cover Photo: Wetlands near the proposed Pebble Mine site in Bristol Bay
Photographed by Glennie LeBaron
Executive Summary:

On Wednesday November 25, 2020, the Trump Administration denied the Pebble Limited Partnership (PLP) a key permit necessary to build Pebble Mine, a colossal proposed gold and copper mine located in Alaska’s Bristol Bay watershed. U.S. Army Corps of Engineers (USACE) Alaska Commander Col. Damon Delarosa stated that USACE rejected the mine’s permit application because the proposed waste treatment plan for Pebble Mine “does not comply with Clean Water Act guidelines,” and “the proposed project is contrary to the public interest.”

Although USACE’s decision will likely impede Pebble Mine’s construction for the foreseeable future, the mining industry stakeholders can still learn a lot from the mistakes made by PLP executives, engineers, and federal regulators. Most notably, the impacts from anthropogenic or human-caused climate change on the Pebble Mine were overlooked by the mine’s critics and under-analyzed by the project’s federal regulators, investors and engineers. Such oversight would have generated substantial unexpected costs for PLP and unnecessarily burdened Pebble’s stakeholders. Anthropogenic climate change will likely impact future ventures similarly if not properly accounted for in mines’ initial planning and regulation.

This report argues that PLP and USACE’s unpreparedness for anthropogenic climate change would have unnecessarily burdened Pebble Mine’s stakeholders with two significant costs: policy costs and operational costs.

First, the mine’s significant fossil fuel emissions would have made the project vulnerable to costly climate change policies that would likely have emerged over the next 50-100 years, requiring that the mine reduce its emissions or pay rising fees. The mine as it is currently designed would have needed to emit significant amounts of greenhouse gasses (GHGs) at every stage of development, operations and closure from direct and indirect sources. At its peak operations, Pebble Mine would have increased global annual anthropogenic GHG emissions by .006% from direct sources alone. Emissions would have been released during a period when the world must reduce emissions and sequester GHGs to avoid the worst consequences of anthropogenic climate change. If the federal government imposed a carbon tax or other GHG emissions restrictions, PLP would have needed to internalize the costs of its massive climate change contribution.

Second, PLP and USACE, the project’s primary federal government regulator, both largely failed to acknowledge the existence of anthropogenic climate change’s impact on Bristol Bay’s hydrological patterns. As a result, they did not, respectively, engineer or regulate the mine to accommodate projected increases in precipitation, flooding, and severe weather events in Bristol Bay. Anthropogenic climate change unpreparedness could have exposed the mine to avoidable operational challenges and costs. The result of such unpreparedness could have resulted in

1 Eilperin and Dennis, “U.S. Army Corps Denies Permit for Massive Gold and Copper Mine in Pristine Alaska.”
operational delays, unexpected costs, and potential environmental hazards to the pristine Bristol Bay wilderness.

Pebble Mine’s unpreparedness for policy and operational costs generated by anthropogenic climate change would have likely led to higher costs and lost revenues for PLP. The effects of decreased revenue extend beyond lost profits for corporate executives and shareholders. The mine also has stakeholders that would have relied on the project’s promised revenue and environmental stewardship. State and local governments, for example, would have relied on Pebble Mine to fund necessary social services and critical infrastructure projects. Reduced profit could have resulted in the termination of promised mining jobs. Finally, the failure to account for anthropogenic climate change impacts could have heightened the risks to Bristol Bay’s profitable salmon fisheries and, consequently, the natural systems, economies, communities, and traditions that rely on them.

From this report, mining industry stakeholders can better understand the economic, environmental, and social incentives of preparing mines to operate in a radically and rapidly changing climate. Pebble Mine received international condemnation for its potential for environmental destruction. As anthropogenic climate change accelerates and climate policies become more stringent, the mining industry’s climate change contribution will only become more heavily scrutinized and regulated. Expediently preparing and adapting to anthropogenic climate change impacts will only benefit mining stakeholders in the long term.
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1. Introduction: Climate Change and the Mining Industry

Most people do not think about climate change when discussing the mining industry. While we typically reserve such scrutiny for oil, gas and coal producers, many mines are highly vulnerable to climate change.

One mine exemplifies these points well. The Red Dog Mine is one of the largest zinc mines in the world and is owned by the Canadian mining giant Teck Resources.\(^2\) It is located in the Northwest Arctic Borough of Alaska near the Kivalina, a Native Alaskan community threatened by coastal erosion and rising sea levels.\(^3\) Red Dog Mine’s facilities have rested on a thick bed of permafrost – ground that remains frozen year round – since operations began in 1989. Permafrost has played a vital role in maintaining the very foundation on which the mine operates and helps to contain minerals that might otherwise affect treatment systems. Then, accelerating permafrost thawing in the arctic region – a trend that began several decades ago\(^4\) – caused the watershed around the large zinc mine to release higher levels of dissolved minerals into the watershed.\(^5\)

The thawing forced Red Dog operators to limit the amount of treated water they normally discharge into a nearby stream. As a result, operators stored water in its tailings reservoir and active mining pit, making high grade ore at deeper levels unavailable, while a new water treatment plant was being constructed. Workers also scrambled to increase the height of the reservoir dam in order to prevent water from overflowing.\(^6\)

Teck Resources’ failure to prepare for the consequences of permafrost thawing now burdens the company financially and threatens Alaska’s economy and environment. The delay in operations caused by the melting permafrost cost Teck Resources $20 million,\(^7\) and lost profits reduced the expected tax revenues generated from the mine. As thawing continues, rapidly undertaken water-management construction projects may create unforeseen negative environmental and financial consequences in the future. These effects could threaten the local ecology, burden nearby communities with additional costs of cleanup, and add to Red Dog’s already-suspect environmental record.\(^8\)

Permafrost thawing in arctic regions is widespread and experts have studied the connection between permafrost thawing and increased rates of dissolved organic minerals being released.\(^9\) Red Dog Mine and the government, however, did not prepare adequately for this known phenomenon.

\(^2\) Herz, “As Arctic Warming Accelerates, Permafrost Thaw Hits Red Dog Mine with $20 Million Bill.”
\(^3\) Climate Visuals, “Rising Sea Levels Threaten Remote Alaskan Village Of Kivalina.”
\(^4\) Arctic Change, “Land: Permafrost.”
\(^5\) Herz, “As Arctic Warming Accelerates, Permafrost Thaw Hits Red Dog Mine with $20 Million Bill.”
\(^6\) Herz.
\(^7\) Herz.
\(^8\) US EPA, “Toxics Release Inventory (TRI) Program.”
\(^9\) Connolly et al., “Groundwater as a Major Source of Dissolved Organic Matter to Arctic Coastal Waters.”
Red Dog Mine’s experience highlights that when mines fail to thoroughly plan for anthropogenic climate change, they generate unnecessary costs for stakeholders. Despite the fact that the Pebble Mine does not rest on permafrost, PLP – like Red Dog – ignored many of the projected impacts anthropogenic climate change would have had on the proposed Pebble Mine.

The report will explain how the Pebble Mine would have been vulnerable to anthropogenic climate change because 1) the project would have emitted significant quantities of GHGs throughout the mine’s lifespan and 2) PLP and USACE did not engineer or regulate the mine to function under rapidly and radically changing hydrological conditions in Bristol Bay. The report goes on to argue that such unpreparedness would have generated significant policy and operational costs, unnecessarily burdening the mine’s shareholders.

2. What is Pebble Mine?

The proposed Pebble Mine would have been located in the Bristol Bay watershed in Southwest Alaska on land owned by the State of Alaska. PLP, owned by the Canadian mining company Northern Dynasty Minerals, controls mining rights to land containing the Pebble deposit. PLP hoped to develop the Pebble deposit – allegedly possessing $300 billion worth of copper, gold, and other valuable metals – by operating an open pit mine more than a square mile wide and a third of a mile deep for 20 or more years. The Pebble Mine would have been the largest mine in North America, generating 67 times more recoverable ore than Red Dog Mine and enough waste to bury the city of Seattle, WA.

Proponents of Pebble Mine argue that developing the Pebble deposit would improve America’s mineral security, provide revenues to the state, and bring high-earning jobs and critical infrastructure to remote Alaskan communities.

Critics of the project note the Pebble Mine would have been a massive open pit mine located at the headwaters of Bristol Bay, one of the last great wild places and home to the largest wild sockeye salmon run on earth. They argue that the Pebble Mine would have wiped out the salmon run by damaging critical spawning habitat and releasing toxic waste into the watershed. Destruction of the salmon run would have uprooted a $1.5 billion annual commercial fishing industry, 14,000 fishing and seafood jobs, and thousands of recreation and tourism industry jobs. Some also claim that the mine would not be economically viable.

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10 Save Bristol Bay, “Mine Proposal.”
11 Fountain and Johnson, “Gold vs. Salmon.”
12 Fountain and Johnson.
13 Save Bristol Bay, “Mine Proposal.”
14 Save Bristol Bay, “Who Benefits?”
16 Bristol Bay Defense Fund, “What’s at Stake.”
On Wednesday November 25, 2020, the Trump Administration denied a key permit for Pebble Mine. Although PLP is appealing, the decision will likely halt the Pebble Project for the foreseeable future. The decision formed a unique coalition between the normally pro-development administration and groups opposed to the Pebble Mine, such as the Bristol Bay fishing industry, environmentalists, and Native Alaskans. On Wednesday November 25, 2020, the Trump Administration denied a key permit for Pebble Mine. Although PLP is appealing, the decision will likely halt the Pebble Project for the foreseeable future. The decision formed a unique coalition between the normally pro-development administration and groups opposed to the Pebble Mine, such as the Bristol Bay fishing industry, environmentalists, and Native Alaskans.

3. Pebble Mine’s Climate Change Contribution

Pebble Mine would have emitted significant quantities of GHGs throughout its lifetime at the mine site and along the project’s roads, pipelines, ports and other facilities through direct and indirect sources.

Direct GHG sources include mining construction, operation, and closure equipment that combust fossil fuels when they operate. Indirect GHG sources do not directly combust fossil fuels when operated but could release GHGs into the atmosphere or prevent the sequestration of GHGs as a result of the mine’s construction, operation, and/or closure. GHGs could have been indirectly emitted through wetlands destruction, pipeline leaks or ruptures, or wildfires caused by mining activities among others.

a. Measuring Pebble’s Direct Fossil Fuel Emissions

The Pebble Project’s projected direct fossil fuel emissions were calculated by USACE and reported in Appendix K4.20: Air Quality of the Pebble Mine Final Environmental Impact Statement (Final EIS) released on July 24, 2020. The Final EIS reported the total metric tons of Carbon Dioxide Equivalent (CO₂-eq) that would have been emitted annually by each project site during each phase of the project. The sites analyzed include the mine site, the transportation corridor, the Diamond Point port, and the natural gas pipeline corridor. The three project phases are construction, operations, and closure. For information about the method USACE used to calculate the measurement CO₂-eq, consult Appendix A.

The figures reported for each phase are estimates and would likely have deviated slightly from Pebble Mine’s actual climate change contribution as the design of the mine evolved to

18 Eilperin and Dennis, “U.S. Army Corps Denies Permit for Massive Gold and Copper Mine in Pristine Alaska.”
19 U.S. Army Corps of Engineers, “Appendix K4.20: Air Quality of the Pebble Project.”
20 U.S. Army Corps of Engineers, 1.
21 U.S. Army Corps of Engineers, 1.
satisfy regulatory and economic restraints. Further, the total emissions were modeled based on what engineers anticipated the sites to produce under Alternative 1a. The US Environmental Protection Agency (EPA) requires that mining companies produce a range of reasonable design alternatives to analyze. Recently, USACE determined that PLP should have pursued Alternative 3, its preferred alternative, rather than Alternative 1a.

The largest differences between the alternatives are the transportation and natural gas pipeline corridor routes and the location of the port site. Alternative 1a’s transportation corridor would have included a shuttle ferry crossing over Lake Iliamna and a port site located near Amakdedori Creek. A natural gas pipeline would have followed the transportation corridor, including an underwater crossing of Lake Iliamna. Alternative 3 eliminates the ferry crossing and would have included a road north of Lake Iliamna. The natural gas pipeline would have followed the road, connecting the mine site to a port site near Diamond Point. Consult Appendix B to better understand the structural differences between Alternative 1a and Alternative 3.

USACE did not calculate precisely the quantity of emissions produced under Alternative 3. Rather, USACE compared projected emissions of Alternative 3’s sites and phases relative to projected emissions generated by Alternative 1a. This report estimates direct emissions for Alternative 3 based on these relative estimates.

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22 U.S. Army Corps of Engineers, 1.
24 Bradner, “Army Corps Chooses Road Alternative for Big Pebble Mine Project, Dropping Plan for Shuttle Ferry across Lake Iliamna.”
25 U.S. Army Corps of Engineers, “Chapter 4: Environmental Consequences Section 20: Air Quality.”
b. Direct Climate Change Contribution

According to the Final EIS, Pebble Mine would have significantly contributed to Alaska’s GHG emissions by directly combusting fossil fuels at all project sites during the construction, operational, and closure phases.\textsuperscript{26}

At peak construction of the Pebble Project, the mine’s four sites would have collectively emitted around 579,283 tons of CO\textsubscript{2}-eq per year. Hilcorp Alaska LCC released a similar amount of GHGs in 2015.\textsuperscript{27} Completing construction of all of the locations over 4 years would have produced approximately 2 million metric tons of CO\textsubscript{2}-eq, equivalent to emissions generated by 500,000 average passenger vehicles driven for one year.\textsuperscript{28}

\textbf{Direct Pebble GHG Emissions By Phase and Site (in metric tons of CO\textsubscript{2}-eq/year)}

<table>
<thead>
<tr>
<th></th>
<th>Construction</th>
<th>Operations</th>
<th>Closure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine Site\textsuperscript{29}</td>
<td>412,226</td>
<td>1,241,260</td>
<td>665,081</td>
</tr>
<tr>
<td>Transportation Corridor\textsuperscript{30}</td>
<td>126,972</td>
<td>30,202</td>
<td>126,972</td>
</tr>
<tr>
<td>Diamond Point Port\textsuperscript{31}</td>
<td>38,753</td>
<td>46,997</td>
<td>38,753</td>
</tr>
<tr>
<td>Natural Gas Pipeline Corridor\textsuperscript{32}</td>
<td>1,332</td>
<td>25,370</td>
<td>1,332</td>
</tr>
<tr>
<td>Phase Total</td>
<td>579,283</td>
<td>1,343,829</td>
<td>832,138</td>
</tr>
<tr>
<td>Annual Emissions of Comparison\textsuperscript{33}</td>
<td>699,843</td>
<td>984,799</td>
<td>851,766</td>
</tr>
</tbody>
</table>

\textsuperscript{26} U.S. Army Corps of Engineers, “Appendix K4.20: Air Quality of the Pebble Project.”
\textsuperscript{27} “Alaska GHG Emissions Inventory,” 37.
\textsuperscript{28} US EPA, “Greenhouse Gas Equivalencies Calculator.”
\textsuperscript{29} U.S. Army Corps of Engineers, “Appendix K4.20: Air Quality of the Pebble Project,” 4.20.2-4.
\textsuperscript{30} U.S. Army Corps of Engineers, 4.20.4-6.
\textsuperscript{31} U.S. Army Corps of Engineers, 4.20.6-8.
\textsuperscript{32} U.S. Army Corps of Engineers, 4.20.8-10.
\textsuperscript{33} “Alaska GHG Emissions Inventory,” 37.
Additionally, Pebble Mine would have produced up to 1,343,829 metric tons of CO$_2$-eq per year during the operations phase if no natural gas leaks occurred, emitting close to 27 million metric tons of CO$_2$-eq over the mine’s 20 year lifetime. Pebble’s annual operations emissions rate would have exceeded stationary annual emissions from the Municipality of Anchorage in 2015 by approximately 350,000 metric tons of CO$_2$-eq.\textsuperscript{34} During operations, Pebble would have become one of the largest GHG producers in the state, increasing Alaska’s CO$_2$-eq annual emissions by 3.4% (according to 2015 levels).\textsuperscript{35}

During the 20-year closure phase, Pebble Mine would have emitted 832,138 metric tons of CO$_2$-eq annually, equivalent to all of the stationary emissions generated by the US military in Alaska in 2015.\textsuperscript{36} Although the mine site would require waste water treatment in perpetuity following the closure phase, USACE did not estimate the quantity of GHGs that would have been produced each year. For a more in-depth breakdown of Pebble Mine’s projected emissions generated by project sites during each phase, see Appendix C.

\textbf{c. Indirect Climate Change Contribution}

This section contains a non-comprehensive list of indirect GHG sources that could have arisen from the mine’s construction and operation. The indirect sources discussed include destroyed wetlands, leaky or ruptured pipelines, and wildfires from the natural gas pipeline and transportation corridor.

\textbf{i. Assimilative Capacity Lost from Wetland Destruction}

PLP’s destruction and disturbance of thousands of acres of wetlands will limit their assimilative capacity, or ability to sequester CO$_2$. As a result, their destruction indirectly adds to Pebble Mine’s climate change contribution.

According to the Final EIS, Alternative 3 would destroy approximately 3,454 acres of wetlands.\textsuperscript{37} Wetlands make up 16% of the land that would be used by all project sites.\textsuperscript{38} These wetlands are “predominantly peatlands,” although USACE provided no further specification in the Final EIS.\textsuperscript{39} Peatlands occur in almost every country on Earth and currently cover around 3% of all land surface area. “The term ‘peatland’ refers to the peat soil and the wetland habitat growing on its surface.”\textsuperscript{40}

\textsuperscript{34} “Alaska GHG Emissions Inventory,” 37.
\textsuperscript{35} Gullufsen, “Report: Alaskans fourth highest greenhouse gas emitters per-capita.”
\textsuperscript{36} “Alaska GHG Emissions Inventory,” 37.
\textsuperscript{37} U.S. Army Corps of Engineers, “Chapter 3: Affected Environment Section 22: Wetlands and Other Waters/Special Aquatic Sites,” 42.
\textsuperscript{38} U.S. Army Corps of Engineer, 42.
\textsuperscript{39} U.S. Army Corps of Engineers, 1.
\textsuperscript{40} Buckmaster, Bain, and Reed, “Peatlands and Climate Change.”
Peatlands are valuable terrestrial carbon sinks because they can sequester massive quantities of atmospheric CO$_2$ into plant tissue. Atmospheric carbon becomes fixed into plant tissue through photosynthesis. In peatlands, “year-round waterlogged conditions slow the process of plant decomposition to such an extent that dead plants accumulate to form peat. Over millennia this material builds up and becomes several meters thick.”

Due to high levels of carbon fixation, peatlands are the largest natural terrestrial carbon sink on earth. There are approximately 3 million km$^2$ or 741 million acres of peatlands worldwide. Each year, peatlands sequester 0.37 gigatones of CO$_2$ annually, storing more carbon than all vegetation types in the world combined. Based on global carbon sequestration rates, an acre of peatland sequesters approximately 0.5 tonnes of CO$_2$ annually.

By destroying 3,454 acres of peatlands, PLP would have inhibited the sequestration of approximately 1727 tons of CO$_2$ per year, or 77715 tons over a 45-year construction-to-closure period. This estimate was calculated using global peatland carbon sequestration rates because the lost assimilative capacity was not calculated by PLP nor included by USACE in the Final EIS.

Destroying peatlands would also release previously-sequestered CO$_2$, contributing to PLP’s indirect climate change contribution. If PLP operators drained Bristol Bay’s peatlands, these wetlands would rapidly release all of the carbon that has been sequestered there for thousands of years, contributing considerably to climate change. “Wetlands International estimates that CO$_2$ emissions from drained or burnt Indonesian peatlands alone total some two billion tons annually, equal to about 10 percent of the emissions resulting from burning coal, oil and natural gas.”

Although peatlands naturally emit CH$_4$, a potent GHG, damaging peatlands by constructing transportation corridors through them increases CH$_4$ production and worsens their climate change contribution. Slow moving water in wetlands generates anaerobic conditions. Soil microbes and plants forced to metabolize in oxygen-deficit locations produce CH$_4$. These emissions, while a substantial contributor to climate change globally, pale in comparison to the climate change impact of peatlands when they are damaged or destroyed. New research by the

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41 Buckmaster, Bain, and Reed.
42 Buckmaster, Bain, and Reed.
43 “How the Loss of Peat Lands Affects Greenhouse Gas Buildup.”
44 ScienceDaily, “Unexpected Culprit.”
American Geophysical Union found that “building roads across [peatlands] for transport and to extract natural resources may boost emissions of \( \text{CH}_4 \)...up to 49 times the natural level.”

Pebble Mine’s proposed transportation corridor route would directly destroy nearly 800 acres of wetlands along the 82-mile route and indirectly damage hundreds of others by inhibiting the natural flow of water though the two-lane gravel road. The \( \text{CH}_4 \) generated by damaging peatlands and other wetlands would add considerably to Pebble’s indirect climate change contribution. USACE did not analyze the impact of wetlands destruction in the Final EIS on climate change and the Pebble Partnership website did not lay out a plan describing any efforts to limit wetlands damage.

ii. Unexpected Emissions from Pipeline Leaks and Ruptures

In the high likelihood of PLP’s 157 mile-long natural gas pipeline failing, significant quantities of \( \text{CH}_4 \) would be leached into the atmosphere and contribute to the Pebble Project’s indirect climate change contribution.

A compressor station north of Anchor Point would pump natural gas through a 75-mile pipeline underneath Cook Inlet to Diamond Point Port Site. Then, the pipeline would be buried and run parallel along the 82-mile transportation corridor until it reaches the mine site. The pipeline would be able to supply the site with up to 50 million standard cubic feet of natural gas per day.

The natural gas pipeline has a high probability of failing during Pebble Mine’s lifetime. “Pipeline failures include both leaks and ruptures. Leaks are small holes and cracks that result in product loss but do not immediately prevent the functioning of the pipeline. Ruptures are larger holes or breaks that render the pipeline inoperable.” Leaks or ruptures are principally caused by external corrosion and mechanical damage. The underground pipeline could fail from damage due to road or pipeline maintenance or as a result of frost heaving. The underseas pipeline is vulnerable to the radically changing conditions of an ocean environment. Both pipeline types could fail from one of the many strong earthquakes that frequent the area.

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45 Garcia de Jesus, “Peatlands Release More Methane When Disturbed by Roads.”
46 “Chapter 3: Affected Environment Section 22: Wetlands and Other Waters/Special Aquatic Sites,” 43.
47 The Pebble Partnership, “Power & Pipeline.”
50 U.S. Department of Transportation, “Fact Sheet: Natural Force Damage.”
Based on previous oil and gas pipeline failure probabilities for pipelines of a similar range, diameter, and location in a climate comparable to Alaska’s, Pebble’s natural gas pipeline has a failure probability of 0.0010 failure/km-yr. The annual failure probability, coupled with a 157-mile pipeline operating for 40 years during the mine site’s operations and closure, the natural gas pipeline is estimated to fail over six times during the Pebble Project’s lifespan.

Natural gas pipeline leaks or ruptures can contribute significantly to climate change. A leak could release hundreds of thousands of cubic feet of CH₄ into the atmosphere for weeks on end before it is discovered and repaired. Hilcorp’s Middle Ground Shoal pipeline cracked after Cook Inlet’s powerful tides caused the pipeline to scrape against sharp rocks in December 2016. The pipe leaked for four months and released between 210,000 to 310,000 cubic feet of CH₄ per day until ice thawed enough to allow Hilcorp to repair the damage.

It is impossible to predict how much CH₄ would have been released in the likely event of multiple small leaks or a few large ruptures. If significant quantities of CH₄ had been released, however, they would have contributed indirectly to the Pebble Project’s climate change contribution.

USACE in the Final EIS does not account for the indirect additional GHG emissions the Pebble Project would produce in the likely event of a pipeline leak or rupture.

iii. Increased Risk of Wildfires from Natural Gas Pipeline and Transportation Corridor

The proposed natural gas pipeline and transportation corridor had a high probability of causing explosions and subsequently starting wildfires. If carbon sinks were destroyed during one of these fires, the lost assimilative capacity of these ecosystems would indirectly contribute to Pebble’s climate change contribution.

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52 US EPA, 11-5.
53 Dougherty, “Hilcorp Alaska Avoids Fines for Cook Inlet Methane Leak.”
A natural gas leak or rupture can cause a significant explosion. From the explosion, especially “during dry periods, a wildfire could result.” For example, on January 24, 2016, a 7.4 magnitude earthquake struck the Cook Inlet region. The quake displaced a distribution line in Kenai and released 406,000 cubic feet of natural gas. The gas ignited, destroying two homes and producing a fire that consumed two more.

Wildfires are more likely to start and spread in Alaska as a result of climate change. Rapidly warming atmospheric temperatures and extended dry periods in the state have heightened the risk and intensity of wildfires. In 2019 alone, Alaskan wildfires destroyed over 2 million acres and emitted roughly three times the amount of GHGs Alaska emits annually from anthropogenic sources. Alaska’s fires produced 40% more CO₂ than California’s destructive 2018 fire season. A natural gas explosion during the dry season in an environment that is increasingly susceptible to wildfires could devastate the Bristol Bay watershed and destroy carbon sinks, thus perpetuating climate change.

Building a transportation corridor through Bristol Bay watershed would also increase the chances of wildfires in the area. A report by the Pacific Biodiversity Institute found that roads were significant contributors to the ignition of wildfires in the US. It found that 88% of all wildfires are caused by humans and 95% of these occurred within ½ a mile of a road. Less than 3% of all wildfires start in wilderness or backcountry areas more than 2 kilometers from a road. Even in Alaska’s vast remote areas, humans were the second highest cause of wildfires in 2019, igniting 291 of the 663 fires. Lightning sparks were the cause of around 361 that year. Building a road north of Lake Iliamna would expand roadway traffic along the road, increasing the likelihood of human-caused forest fires in Bristol Bay.

The potential climate change contribution of human-caused fires stemming from the transportation corridor or natural gas pipeline explosions were not calculated or acknowledged by USACE in the Final EIS.

To summarize, the last three sections have reviewed three different indirect sources of GHGs stemming from the Pebble Project: GHG emissions from destroyed or damaged wetlands, CH₄ emissions from natural gas pipeline leaks or ruptures, and GHG emissions from forest fires started along the transportation corridor or from pipeline explosions. Wildfires and wetland destruction would additionally inhibit future sequestration of carbon for hundreds of years.

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55 Neyman, “Enstar Identifies Cause of Gas Explosions in Kenai.”
56 Phillips, “What Do Alaska Wildfires Mean for Global Climate Change?”
58 Law, “About 2.5 Million Acres in Alaska Have Burned. The State’s Fire Seasons Are Getting Worse, Experts Say.”
While it is impossible to calculate the exact probability of these events occurring, PLP and USACE should not have disregarded the contribution of indirect GHG emissions to climate change. Each of the events, should they have occurred, could have released significant quantities of potent GHGs. In the following section, I will discuss how PLP’s disregard for its direct and indirect climate change contribution could have made the mine vulnerable to costly new climate change policy.

b. Policy Costs: Vulnerability to Adapting Climate Change Policy

The state or federal government would likely have required operators to reduce the project’s massive climate change contribution or pay a high price to continue directly or indirectly emitting GHGs during the mine’s long lifetime. These policies mandating reductions in GHG emissions would have imposed significant financial challenges on PLP.

Global atmospheric GHG concentrations must be reduced in order to avoid the worst consequences of anthropogenic climate change. The 2018 IPCC Special Report on Global Warming of 1.5°C clearly stated that atmospheric warming should not exceed an increase of 1°C above pre-industrial temperatures in order to maintain a climate that can sustain human society. In order to prevent excess warming, atmospheric CO$_2$ concentrations must be decreased from the current status of 410 ppm to 350 ppm by the end of the century. To achieve 350 ppm by 2100, the nations of the world must all reduce their CO$_2$ emissions and sequester GHGs already in the atmosphere. In the US, CO$_2$ emissions must be reduced by approximately 80% by 2030 and close to 100% by 2050.

At the project’s peak operations, PLP was projected to be one of Alaska’s largest GHG emitters. In the Final EIS, USACE finds that the Pebble Project as planned would have increased global CO$_2$ emissions by .006% annually. This calculation does not take into account Pebble Mine’s potential indirect climate change contribution or its planned destruction of vital carbon sinks.

The US government likely would not have allowed PLP to emit such significant quantities of GHGs over the next half century during a time when GHGs must be reduced. Restrictions on Pebble Mine’s emissions could have come in many forms. Even if President Trump did not veto the Pebble Mine permit, President-elect Joe Biden promised to do so just as President Obama did in 2014. Even if Biden allowed Pebble Mine to begin operations, Biden campaigned on several environmental and climate change policies that, if implemented, would have restricted Pebble Mine’s emissions. These policies include proposals to reduce GHG emissions from the

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59 “Government Climate and Energy Actions, Plans, and Policies Must Be Based on a Maximum Target of 350 Ppm Atmospheric CO2 and 1°C by 2100 to Protect Young People and Future Generations,” 1.
60 “Government Climate and Energy Actions,” 11.
61 “Chapter 4: Environmental Consequences Section 20: Air Quality,” 21.
62 DeMarban, “Joe Biden Says He’ll Work to Stop Pebble Mine If He Wins Presidency.”
transportation sector, require public companies to discuss their climate risks and emissions, and introduce new green standards for manufacturing, mining, and tourism.\textsuperscript{63}

Over its lifetime, PLP would have likely needed to reduce the project’s footprint or pay a high price for continued emissions. These policy changes would generate significant and unexpected policy costs.

Despite the significant risks of evolving climate change priorities to the project, PLP and USACE did not provide any evidence that Pebble Mine engineers would have been capable of reducing the project’s planned GHG emissions levels under financial, operational, and environmental constraints. In fact, USACE even attempted to undermine the scale of the project’s massive climate change contribution by calling Pebble’s climate change contribution “extremely small” compared to the 32 gigatons of CO\textsubscript{2} emitted globally.\textsuperscript{64}

Adapting climate change policy is not Pebble Mine’s only climate change vulnerability. In the following section, the report introduces a second complication; PLP and USACE’s neglect in preparing for anthropogenic climate change impacts in Bristol Bay have left the project vulnerable to operational challenges.

4. Lack of Preparedness for Climatological Changes in Bristol Bay
   a. Climate Change in Bristol Bay

Atmospheric warming in Bristol Bay is significantly altering the current hydrological conditions of the watershed, resulting in an increase in precipitation, more frequent severe weather events and flooding, and less favorable conditions for Bristol Bay’s sockeye salmon.

A multi-model average of annual air temperature in the Bristol Bay region predicts air temperature will increase by approximately 4\textdegree C by the end of the century, with an approximate 6\textdegree C increase in air temperature in the winter season, if atmospheric GHG concentrations are not reduced. Higher air temperatures will affect “the accumulation and melt of snowpack, the extent of lake ice, and the timing of spring ice break up,”\textsuperscript{65} altering the current hydrological conditions in Bristol Bay.

Some of the expected hydrological changes include increases in precipitation. Scientists predict that precipitation in the watershed will increase roughly 30\%, for a total increase of approximately 250 mm annually by the end of the century. Further, precipitation is expected to increase in all four seasons.\textsuperscript{66}

\textsuperscript{63} “Plan for Climate Change and Environmental Justice | Joe Biden.”
\textsuperscript{64} “Plan for Climate Change and Environmental Justice,” 21.
\textsuperscript{65} US Environmental Protection Agency, “An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay Alaska,” 3-36.
\textsuperscript{66} US Environmental Protection Agency, 3-36.
Higher air temperatures will also intensify the severity of extreme precipitation and weather events. Future climate change modeling suggests that there will be a greater chance of rain-on-snow events. Medium sized and 100-year storms are also expected to become more frequent. The combination of on-average higher rates of precipitation and increasing frequency of extreme weather events will increase the likelihood of flooding in Bristol Bay.  

Climate change in Bristol Bay will also endanger the world’s biggest sockeye salmon run by introducing a variety of new stressors into their habitat. Every June, over 50 million sockeye salmon flood Bristol Bay’s rivers, providing sustenance for local communities and contributing to two-thirds of Alaska’s salmon fishery economy. Climate change has contributed to the formation of “the Blob,” warm nutrient-poor waters off the Northwest Pacific Coast. Such conditions have decreased the productivity of the salmon food chain and may confuse salmon trying to find their way inland. Even if the salmon make their way inland, warming atmospheric temperature has increased the temperature of freshwater streams, “making salmon more susceptible to predators, parasites and disease.” The heat, which has reduced snowpack and caused glaciers to retreat, will also result in less waters in rivers and streams, making it more difficult for salmon to travel. More severe storms and more frequent flooding has increasingly washed away salmon eggs and destroyed spawning habitat. Unless global GHG atmospheric concentrations are reduced, such stressors will only worsen in the future, endangering the vitality of the Bristol Bay sockeye salmon population.

b. Denial of Anthropogenic Climate Change

By denying the scientific consensus of anthropogenic climate change, PLP and USACE failed to, respectively, engineer and regulate Pebble Mine to adapt to future known climate change impacts in Bristol Bay.

PLP engineered Pebble Mine to withstand natural fluctuations in precipitation and climate expected over the mine’s lifespan. In a Water Management video on the Pebble Partnership website, for example, PLP stated that it planned to enlarge the mine site’s main water management pond to accommodate “multi-year climate precipitation variability.” “Multi-year climate precipitation variability” refers to the normal long-term changes in climate and precipitation that would occur with or without the influence of anthropogenic climate change.

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67 US Environmental Protection Agency, 14-16.
68 World Wildlife Fund, “Sockeye Salmon and Climate Change.”
69 World Wildlife Fund.
70 The Pebble Partnership, “Water Management.”
The Water Management video was PLP’s only statement on its website discussing how mining engineers had prepared the mine for a changing climate.

While it is necessary that PLP plan for variable precipitation influenced by natural long-term climate change, PLP presented no evidence that they engineered the mine to function in an environment influenced by anthropogenic climate change. Unlike long-term natural climate change, anthropogenic climate change will rapidly and radically alter the past century’s hydrological patterns. PLP did not demonstrate in the information available to the public that its current design would have accommodated increasing rates of precipitation, flooding, and extreme weather events expected over the mine’s lifetime.

Throughout the Final EIS, USACE also failed to mention the scientific consensus that anthropogenic climate change exists and denied evidence that it is changing hydrological patterns in Bristol Bay. USACE in the Final EIS claims that “although there seems to be general agreement that average annual temperature has been increasing, there does not seem to be agreement on the cause of the change. Most likely, it is related to a combination of long-term climate change and a shift in the Pacific Decadal Oscillation (PDO).” It is true that the PDO and other natural factors will contribute to rising temperatures in Bristol Bay and the mine must be built to adapt to these changes. This statement is problematic, however, because there is a scientific consensus that anthropogenic climate change exists and will radically and rapidly change Bristol Bay’s climate and hydrological patterns.

USACE also denies that anthropogenic climate change is altering the hydrological patterns in Bristol Bay. USACE in the Final EIS states that long-term studies of Bristol Bay’s climate could not conclude that there was any increase in annual precipitation rates, extreme weather events, or flooding. As a result, they concluded that “there is considerable uncertainty about whether long-term climatic change is influencing the hydrology of the area; and if so, what the magnitude of the change might be.”

This conclusion is problematic for two reasons. First, USACE’s conclusion was based on the findings from a 2019 study by Knight Piésold Consulting, a firm that assists mining, oil and gas, and other natural resource extractors in conducting environmental-impact assessments. PLP’s inconclusive findings may be the result of cherry picking the information that suited the conclusions they desired.

Additionally, the findings by Knight Piésold contradict with the assessment that the EPA released in 2014 validating that anthropogenic climate change has already and will increasingly influence Bristol Bay’s hydrology in the future. The EPA report states that “there is limited

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71 United States Environmental Protection Agency, “An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay Alaska.” 3-34
72 Ibid. 30
73 NOAA, “Scientific Consensus: Earth’s Climate is Warming.”
74 “Chapter 4: Environmental Consequences Section 16: Surface Water Hydrology,” 30.
75 Knight Piésold Consulting, “About - Knight Piésold.”
evidence over the last decade that suggests air temperature in much of Alaska has cooled, due to changes in the Pacific Decadal Oscillation and weakening of the Aleutian low (Wendler et al. 2012).” Rather, “over the past 60 years, much of Alaska has been warming at twice the average rate of the United States and many parts of the world (ACIA 2004). Throughout Alaska, warming temperatures, melting glaciers, declining sea ice, and declining permafrost have already begun (Serreze et al. 2000, Stafford et al. 2000, ACIA 2004, Hinzman et al. 2005, Liston and Hiemstra 2011, Markon et al. 2012).”  

In summary, USACE’s Final EIS contradicts with the EPA’s findings that climate change is already and will continue to affect Bristol Bay’s hydrology.

By denying the fact that anthropogenic climate change has already altered and will continue to influence Bristol Bay’s hydrology, USACE did not adequately assess if Pebble Mine’s current design would have been able to operate under radically different conditions. When USACE concluded falsely that there is considerable uncertainty about whether climatic change is influencing Bristol Bay’s hydrology, regulators decided that it “seems reasonable” to use “76 years of synthetic record” collected by Knight Piésold that were “based on actual temperature and precipitation measurements made in the vicinity of the mine to estimate the water balance at the mine” during its lifetime.

Using historical temperature and precipitation patterns over the past 76 years was a problematic method to design the mine’s water management system. EPA climate models predict Bristol Bay will experience significant changes in the type and timing of precipitation, decreased snowpack and earlier spring snowmelt, and an increased risk of flooding by the end of the century.  

Using patterns of precipitation and temperature over the last 76 years to model a water management system at the mine site will not account for the expected increase in annual precipitation and extreme precipitation events.

Failing to accurately predict hydrological or other variable climatic conditions around a mine site could reduce mines’ profitability, degrade the surrounding environment, and harm nearby communities. For example, Minto Mine, a copper and gold mine in Canada, released untreated water into the Yukon River system in 2008 when torrential rainfall overburdened water management systems in the mine pit and across the mine site. Pebble Mine could have experienced similar water management problems if the mine was not engineered to manage projected variable hydrological patterns.

PLP failed to demonstrate that they engineered the mine to function under radically and rapidly changing conditions exacerbated by anthropogenic climate change. USACE failed to mention the scientific consensus that anthropogenic climate change exists and denied evidence that it is

76 US Environmental Protection Agency, “An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay Alaska,” 3-34.
77 “Chapter 4: Environmental Consequences Section 16: Surface Water Hydrology.” 30
78 U.S. Army Corps of Engineers, “Chapter 4: Environmental Consequences Section 16: Surface Water Hydrology.” 3-34.
79 US Environmental Protection Agency, 14-16.
changing hydrological patterns in Bristol Bay. Shortcomings in PLP’s engineering and USACE’s analysis cast doubt on what the mine’s true environmental impact would have been.

In the following section, a non-comprehensive list of challenges Pebble Mine operators would likely experience in part due to climate change is recorded. These challenges have been ignored by PLP and USACE, creating significant economic risks for the mine.

c. Operational Costs: Unpreparedness for Future Operational Challenges

Since PLP engineers did not design or regulate the mine to withstand future anthropogenic climate change impacts, operators would have experienced numerous operational and environmental challenges throughout the mine’s lifetime. The following section contains a non-comprehensive list of a few of the known challenges Pebble Mine operators would have encountered during the project’s lifespan due to PLP’s climate change unpreparedness:

1. **Damages to the Mine Site:** The predicted increase in precipitation, flooding, and intensifying extreme weather events could have damaged mine infrastructure such as buildings, waste rock piles, tailings storage facilities, and water retention facilities. Damages could have occurred to mine infrastructure because flooding and storms can weaken the structural integrity of facilities, increase embankment instability, and accelerate erosion. This in turn would have increased the probability of a tailings dam failure, overtopping of ponds, and the flooding of water management facilities. All of these events, if unplanned for, could have resulted in the unintended release of untreated toxic water into Bristol Bay’s fragile salmon spawning habitat.\(^{80}\)

2. **Damages to the Transportation Corridor:** More precipitation would have increased the probability of floods and landslides, potentially damaging the roadway and causing delays. Greater flood frequencies and faster erosion and sedimentation would likely have affected streams and wetlands along the transportation corridor. Changes in precipitation patterns resulting in rapid snowmelt and high rates of debris issues and sedimentation could also have increased the likelihood of culvert, pipeline, and bridge failures along the transportation corridor.\(^{81}\)

3. **Water Management Challenges:** Water management under a stable climate would have been a challenge for Pebble Mine operators. Anthropogenic climate change, by impacting temperature, precipitation, evapotranspiration, hydrology, and seasonal flooding and drying patterns, would have heightened this challenge. Transformations in water availability and groundwater recharge would have affected the amount and timing of water available for the mine to utilize. Climate change could have also affected the hydrological gradients of groundwater in and around the mine site, necessitating that adjustments be made to the water management plans in the mine pit and water treatment facilities.\(^{82}\)

\(^{80}\) US Environmental Protection Agency, 14-16.
\(^{81}\) US Environmental Protection Agency, 14-16.
\(^{82}\) US Environmental Protection Agency, 14-16.
4. **Cumulative Effects on Salmon:** As previously discussed, climate change will pose significant challenges to Bristol Bay's sockeye salmon population. The mine would have imposed additional stressors to the fragile habitat, such as destroying more than 80 miles of salmon streams and building a private transportation route that would have crossed 200 additional streams. The mine site would have also included a pit lake containing 60 billion gallons of toxic mine waste that could have leaked into salmon spawning regions. Dams and embankments would have blocked off critical salmon habitats. The combination of climate change and mining in Bristol Bay would have complicated mine operators’ attempts to measure Pebble Mine’s direct damages to the salmon run. Minimizing PLP’s damages to salmon in a changing climate would have required making costly operational and salmon monitoring changes.84

There is currently no public information assuring that PLP has or will take steps to address the above-mentioned operational concerns. If climate change denialism prohibits PLP’s climate change preparedness, officials would be confronted with unanticipated costs that will burden the mine’s stakeholders.

5. **Unanticipated Costs for Pebble’s Stakeholders**

To summarize, Pebble Mine is vulnerable to policy costs and operational costs as a result of failing to prepare for anthropogenic climate change. First, operators would be challenged to reduce Pebble Mine’s massive climate change contribution to align with evolving societal norms and emission standards. Second, as a result of PLP and USACE’s neglect to address anthropogenic climate change in engineering and regulating Pebble Mine, mine operators would not have been prepared to accommodate future climatological and hydrological changes to Bristol Bay.

Decreased revenue would not just harm PLP; it would also burden Pebble Mine’s many stakeholders, including investors, Alaska state and borough governments, mine employees, and local communities in a variety of ways.

The following sections outline some of the consequences of Pebble Mine’s climate change vulnerability to each stakeholder group. In doing so, they demonstrate the consequences future mining companies will face if they fail to fully prepare for anthropogenic climate change impacts.

a. **Lost Profit for Shareholders**

Pebble Mine’s shareholders would have likely received a lower return-on-investment as a result of PLP and USACE’s failure to plan for anthropogenic climate change.

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83 Earthworks, “Alaska’s Bristol Bay at Risk from the Pebble Mine.”
Although PLP failed to produce an economic feasibility study, PLP alleges that a 20-year mine operation would generate $1 billion in profit. Many experts and investors, however, called into question Pebble Mine’s profitability without even considering operators’ unpreparedness for anthropogenic climate change. For example, in an analysis prepared for the NRDC, Richard Borden, a former permitting expert at the mining giant Rio Tinto, found that “the proposed 20-year mine will actually lose $3 billion. He said Pebble is drastically underestimating initial construction costs, assuming billions in infrastructure help from a third party like the state of Alaska, inflating metals prices without also inflating startup capital and operating costs, and low-balling operating and post-closure water treatment costs.”

Many former Pebble Mine investors withdrew from the project as a result of economic concerns. For example, Anglo American, Northern Dynasty’s former partner, withdrew from the project in 2013, “walking away from more than $500 million in sunk costs and making no effort to renegotiate the terms of its deal.” They did so because Anglo American analysts viewed the Northern Dynasty’s economic analysis as “unrealistic and overly optimistic.”

Considerable investor uncertainty over the project’s feasibility demonstrates that Pebble Mine would likely have operated at very low profit margins. Accounting for the additional costs that PLP would likely have incurred due to anthropogenic climate change unpreparedness casts even greater doubt over the mine’s economic feasibility. Short term losses due to an environmental disaster could have temporarily reduced shareholder dividends. Sustained losses stemming from laws restricting emissions or long term environmental concerns could have pushed PLP into bankruptcy.

b. Alaska State and Borough Governments
   i. Structure of the Alaskan Mining Tax System

In 2018, the mineral industry generated $144.7 million in government revenue for Alaska’s state and local governments. This revenue is generated by the Mining License Tax, State Corporate

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86 Save Bristol Bay, “Northern Dynasty Minerals Ltd.: The Pebble Deposit Isn’t Commercially Viable.”
Income Tax, state mineral rents and royalties, payments to municipalities, and other miscellaneous fees.\(^{88}\)

The Alaska Mining License Tax (AMLT) generated $58.8 million in revenue to the state government in 2018. The largest mines with a net income greater than $100,000 pay 7% of their net income to the state government.\(^{89}\) The Corporate Income Tax is the second largest revenue source from the mineral industry, generating $34.6 million in 2018. The largest corporations pay 9.4% of net income.\(^{90}\) “Revenue payments to the state, other than the mining license and the state corporate income taxes, are determined by the land status of the mine. The state collects rents (based on acreage) and royalties (3% of net income) on mines” such as Pebble that operate on state lands. Some of these royalties are deposited directly into the Alaska Permanent Fund."\(^{91}\) In 2018, the mining industry generated $755,234 for the Permanent Fund. Additionally, mines paid $34.2 million in property taxes to boroughs around Alaska.\(^{92}\)

Based on the Final EIS report, Pebble Mine would generate $25 million annually through the State Corporate Tax during its 5-year construction period. During the operations phase, Pebble Mine would bring in $64 million annually through the State Corporate Tax and $41 million annually through the State Mining License Tax (in 2011 dollars). The project would generate $20 million annually (in 2011 dollars) in state royalty payments during the operations phase. Pebble Mine would also generate $27 million annually in Borough Severance Taxes for the Lake & Peninsula Borough (LPB). The Kenai Peninsula Borough (KPB) would also receive 4.7% of the value of all assessed taxable property value.\(^{93}\)

**ii. Reduced Tax Revenue and Social Services**

USACE predicts that the mine would generate millions of dollars in state and local taxes during construction and operational phases. Total tax revenue predictions are based on projections of what the mine’s net profit will be. Net profit is determined by the uncertain prices of copper and gold, operational costs, tax rates, etc. As shown in above sections, PLP has failed to prepare for future climate change perturbations and, as a result, would likely experience significant additional operational costs that would decrease net profit. A decrease in net profit would lead to less tax levied by the AMLT, Corporate Income Tax, mine royalties, and Borough Severance Taxes, resulting in less revenue for state and local governments.

Proponents of Pebble Mine argue that the mine would improve crucial social services to nearby communities as a result of tax revenue levied by the LPB. For example, the Final EIS report

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\(^{88}\) "Mining Taxation in Alaska," 4.
\(^{89}\) "Mining Taxation in Alaska," 4.
\(^{90}\) "Mining Taxation in Alaska," 5.
\(^{91}\) "Mining Taxation in Alaska," 5.
\(^{93}\) “Chapter 4: Environmental Consequences Section 3: Needs and Welfare of the People - Socioeconomics,” 11-12.
argues that “an increased revenue stream to the LPB, along with stabilization of population levels attributable to employment opportunities, could result in improvements to community health care facilities,” and “water, wastewater, and solid waste services and facilities” throughout the borough. Proponents also argue that increased tax revenue would go towards keeping rural schools open and helping administrators expand services for the community.

The projected benefits of Pebble Mine, such as improvements to sewage facilities, health care access, and the local school system in LPB, would be reduced if LPB receives significantly less tax revenue than expected to sustain funding to crucial community infrastructure as a result of lower mine revenue.

c. Lost Employment Opportunities

PLP anticipates that “the project will generate 750 to 1,000 direct jobs for Alaskans and 1,500 to 2,000 jobs overall” with an average mining wage of $100,000. Should the project experience major unexpected environmental setbacks exacerbated by a changing climate or need to dramatically reduce its GHG emissions, PLP may not be able to afford to hire its projected workforce in the long term. Thus, the benefit of Pebble Mine to Alaska miners and local communities could be reduced.

d. Taxpayers and Local Communities Burdened with Environmental Cleanup

As noted in Section 4c, Pebble Mine’s lack of climate change preparedness would increase the likelihood of damages to the mine site, transportation corridor, water management system during operations. There would be additional risks to environmental damage after reclamation. PLP will construct a dam that is nine miles wide and approximately 700 feet tall. The dam will contain billions of tons of acid-generating pyritic tailings produced by processing the ore. Over 99% of the mined ore and waste rock will remain on the mine site permanently after the mine’s closure. The tailings dams, among the largest in the world, must withstand climatological and seismic events in perpetuity. Uncertainty about climate change impacts after 2050 make it difficult to design a sustainable tailings dam, increasing the probability of a catastrophic release of toxic tailings into the Bristol Bay watershed.

In the likely event that Pebble is unable or not required to pay for environmental damage that results during or after mining operations, that burden would be placed on state and federal taxpayers. If the damage is not cleaned up, the long term environmental and public health costs

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94 “Chapter 4: Environmental Consequences,” 8.
95 “Chapter 4: Environmental Consequences,” 7.
96 Save Bristol Bay, “Who Benefits?”
would be placed on downstream Alaska Native communities and those that rely on the long term health of Bristol Bay's profitable salmon spawning habitat.

6. Conclusion

This report argues the Pebble Mine is vulnerable to climate change for two reasons. First, the mine would rely on the emission of GHGs and the destruction of carbon sinks to develop the Pebble deposits. As a result, Pebble Mine is not prepared for new policies that may impose unexpected costs on PLP or mandate that operators reduce emissions. Second, PLP and USACE failed to design and engineer the mine to operate under radically and rapidly evolving climatological and hydrological conditions in Bristol Bay. The result may be damages to the mine site and transportation corridor, wastewater mismanagement, and the accidental release of toxins into Bristol Bay’s vulnerable salmon spawning habitat.

Both gaps in foresight, if they had not been corrected, would have generated unexpected policy costs and operational challenges that would burden stakeholders such as shareholders, taxpayers, mine employees, and local communities.

The findings of this report provide important lessons to minding industry shareholders. Mining executives and engineers must accept the scientific consensus on anthropogenic climate change and design their projects to operate safely and economically in changing environments. Federal and state regulators must also acknowledge the scientific consensus of anthropogenic climate change and analyze future projects’ environmental and economic impact through a climate change lens. Lastly, shareholders must demand from mining companies and regulators a transparent and thorough environmental impact assessment. Not doing so could jeopardize the feasibility of the mining operations and harm surrounding communities, the economy, the local ecology, and the climate.
Appendix A: How USACE Measured Pebble’s GHG Emissions

USACE reported that the following GHGs would have been produced at various stages and sites of the Pebble Project: Carbon Dioxide (CO₂), Methane (CH₄), and Nitrous Oxide (N₂O). Each GHG has a different global warming potential, or the amount of energy a metric ton of gas will absorb and contribute to global warming. One metric ton of CH₄ and one metric one ton of N₂O, respectively, have 25 and 298 times the global warming potential as one metric ton of CO₂. The measurement Carbon Dioxide Equivalent (CO₂-eq) can be used to compare and combine the total global warming potential of multiple GHGs. The CO₂-eq recorded is an estimate of the combined global warming potentials of emitted CO₂, CH₄, and N₂O. This report’s estimate of the Pebble Mine’s total CO₂-eq emissions during each project phase is based on a combination of the projected emissions from each site.

Appendix B: Structural Differences Between Alternative 1a and 3

Alternative 1a and 3 would have emitted slightly different quantities of GHGs as a result of differences in their designs. Alternatives 1a and 3 consist of the proposed mine site, a transportation corridor, and a natural gas pipeline corridor that would have connected the mine site to a port located on the west side of Cook Inlet. The largest differences between the alternatives are the transportation and natural gas pipeline corridor routes and the location of the port sites.

The transportation corridor in Alternative 1a consists of a 35 mile long mine access road, an Iliamna Lake ferry crossing, and a 37 mile port access road. The port access road would connect to Amakdedori port located near Amakdedori Creek. A natural gas pipeline would run from existing natural gas supply infrastructure north of Anchor Point on the Kenai Peninsula across Cook Inlet to Amakdedori port, connect to the South Ferry Terminal on Lake Iliamna, cross the lakebed and ashore between the communities of Iliamna and Newhalen, and run along the Mine Access Road to the mine site.

The transportation corridor and natural gas pipeline in Alternative 3 would connect the mine site and Diamond Point port in Iliamna Bay via a northern access route. Instead of crossing Lake Iliamna via a ferry, an 82-mile road would circle to the northern shore, eliminating the need for a ferry. The natural gas pipeline would run adjacent to the road connecting the mine site and Diamond Point port. A 75 mile-long subsea section of the pipeline would then connect Diamond Point Port to existing natural gas infrastructure North of Anchor Point.

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100 Eurostat Statistics Explained, “Glossary: Carbon Dioxide Equivalent.”
102 U.S. Army Corps of Engineers, 36-41.
Appendix C: Breakdown of Direct Pebble GHG Emissions By Phase and Site

a. Construction

The construction phase of the mine includes building the mine site, the transportation corridor, the Diamond Point port, and the natural gas pipeline corridor.\(^{103}\)

1. Mine Site

Direct emissions during the construction of the mine site under all alternatives would have been “related to quarry crushing operations, concrete batch plant operation, incineration, and power generation.” Emissions were calculated assuming that each emission unit would be operated continuously 24 hours a day, 7 days a week, for a total of 8,760 hours per year.\(^{104}\)

Constructing the mine site as planned would emit 412,226 metric tons of CO\(_2\)-eq per year.\(^{105}\)

2. Transportation Corridor

During construction of the transportation corridor, “the main direct emission sources would be heavy-duty, non-road, and mobile construction vehicles, as well as fugitive dust generated by vehicles on unpaved roads, and wind erosion. Additional fugitive emissions would result from blasting, drilling, rock crushing, and material handling. Stationary emissions sources would include engines and vapor vented from fuel storage tanks. Emissions from material mining and

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\(^{103}\) U.S. Army Corps of Engineers, “Appendix K4.20: Air Quality of the Pebble Project.”

\(^{104}\) U.S. Army Corps of Engineers, 2.

\(^{105}\) U.S. Army Corps of Engineers, 2.
crushing operations required for fill material, principally for an earthen access causeway at the port [under Alternative 1] are also included in this assessment.”

Constructing the transportation corridor under Alternative 1 would emit 126,972 metric tons of CO$_2$-eq per year. The air quality and climate change contribution of constructing Alternative 3 would be “similar to Alternative 1a. However, different geographic areas would be affected along the transportation corridor.”

3. Diamond Point Port

Constructing the port and offshore pipeline use similar equipment and methods. Therefore, their emissions are calculated together. Construction of the port and offshore pipeline would include “engines, an asphalt plant, boilers, fuel storage tanks, and a small incinerator. The mobile equipment inventory would include bulldozers, excavators, loaders, and cranes in the port construction, and tugs, long-reach excavators, and welders in the pipeline construction. Fugitive emissions would result from site grade preparation and mobile equipment traffic. The construction of the port and offshore pipeline would be expected to take approximately 1 year.”

Constructing the Amakdedori port and the offshore pipeline as planned would emit 38,753 metric tons of CO$_2$-eq per year. Constructing the Diamond Point port and the offshore pipeline would likely have a similar carbon footprint because the Final EIS predicts the impacts would be similar to Alternative 1a but in a different geographic area.

4. Natural Gas Pipeline Corridor

Building the on-shore portion of the natural gas pipeline corridor requires several components. “Construction of the compressor station would involve site grading and mobile equipment use for assembly of the compressor station from pre-constructed modules. The compressor station emissions inventory would include engines and mobile equipment, as well as bulldozers, loaders, excavators, cranes, and light-duty vehicles. The fuel-burning equipment would be sources of combustion-related air pollutant emissions. Fugitive dust emissions would result from site grade preparation and mobile equipment traffic.”

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106 U.S. Army Corps of Engineers, 5.
110 U.S. Army Corps of Engineers, 7.
Constructing of the natural gas pipeline corridor as planned would emit 1,332 metric tons of CO$_2$-eq per year under Alternative 1a. Alternative 3 would be “similar” to Alternative 1a but in a different geographical area.

b. Operations
   i. Mine Site

“Direct emissions during mine site operations under all alternatives would be related to mining activities, ore-processing activities, incineration, and power generation. The mine site stationary emission unit inventory would include a combined-cycle combustion turbine 270-megawatt power plant, fire water pump natural gas engines, a back-up diesel generator, boilers, fuel storage tanks, and a small waste incinerator. The mobile equipment inventory used for various mining activities would include haul trucks, bulldozers, graders, shovels, light-duty vehicles, and loaders. Fugitive emissions would result from blasting and drilling in the pit and quarries, vehicle traffic on unpaved roads, and material handling. The fuel-burning mobile and stationary emission units are sources of combustion-related air pollutant emissions.”

Operations at the mine site would produce 1,241,260 metric tons of CO$_2$-eq per year during the mine’s 20 year lifetime.

   ii. Transportation Corridor

Direct emissions during the operations of a transportation corridor under Alternative 3 “would come from power generators at the ferry terminals, shipping across the waterways, vapor vented from fuel storage tanks, and other fuel-burning engines such as ferry engines, light-duty vehicles, truck/trailer vehicles, container-handling forklifts, graders, and aircraft.”

The transportation corridor under this alternative would produce 30,202 metric tons of CO$_2$-eq per year during the mine’s 20-year lifetime. Impacts of Alternative 3 would be “similar to or less than Alternative 1a” and produce dust and vehicle emissions in a different geographic area.

   iii. Diamond Point Port

Diamond Point port emissions “would include power generator engines, heaters, vapor vented from fuel storage tanks, and a small incinerator. Mobile equipment would include light-duty

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116 U.S. Army Corps of Engineers, 3.
117 U.S. Army Corps of Engineers, 5-6.
vehicles, skidsteers, forklifts, and container-handling forklifts. Marine vessels would include barges, tugs, and bulk carriers at the lightering locations.”

Operating the Amakdedori port would emit 46,997 metric tons of CO$_2$-eq per year during the mine’s 20-year lifetime under Alternative 1a. The Diamond Point port would have a similar impact to the Amakdedori port in a different geographic location.

iv. Natural Gas Pipeline Corridor

USACE claims that “the direct emissions from the onshore and offshore pipelines would be minimal” during the operations of the pipeline corridor. “The Kenai compressor station, which would be the single compressor station for the natural gas pipeline, would have emissions. The Kenai compressor station inventory would include natural-gas-fired simple-cycle combustion turbines.” By their measurements, operating the natural gas pipeline would emit around 25,370 metric tons of CO$_2$-eq per year under Alternatives 1a and 3.

In this analysis, however, USACE does not account for indirect GHG emissions produced in the likely event of a pipeline leak or rupture. See section b2 for an analysis of the additional carbon footprint of the natural gas pipeline.

b. Closure:

i. Mine Site

During closure of the mine site under all alternatives, facilities “would support operation of the camp and power generation. The reclamation emissions inventory would include internal combustion engines, a gas turbine, boilers, and an incinerator. The mobile equipment would include haul trucks, shovels, bulldozers, compactors, graders, and service and light-duty vehicles. Fugitive dust emissions would result from stockpiled overburden handling, bulldozing, grading, vehicle traffic on unpaved roads, and wind erosion of road surfaces and active reclamation areas. The duration of the closure phase at the mine site is expected to be approximately 20 years.”

Closing the mine site as planned would emit 665,081 metric tons of CO$_2$-eq per year.

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120 U.S. Army Corps of Engineers, 8.
123 U.S. Army Corps of Engineers, 10.
124 U.S. Army Corps of Engineers, 3-4.
125 U.S. Army Corps of Engineers, 4.
ii. Transportation Corridor

USACE did not model emissions generated by the transportation corridor during the mine’s closure for any alternatives. The Final EIS does state that “the closure and construction activities and emissions in a given year [at the mine site] would be similar” under Alternative 1a. Further, transportation corridor emissions for Alternatives 1a and 3 would be similar and depend on agreements about the public use. Therefore, the transportation corridor would likely generate approximately the same emissions as its construction, 126,972 metric tons of CO2-eq per year, for the 20-year closure period.

iii. Diamond Point Port

Although emissions for the port site during the mine’s closure were not modeled for any alternative, “the impacts are expected to be similar to those outlined for the port construction, because the activities that would occur in a given year are similar.” Further, Alternative 1a and 3 are predicted to produce similar amounts of GHGs. As a result, the port during the closure would likely emit approximately the same emissions as its construction, 38,753 metric tons of CO2-eq per year, during the 20-year closure period.

iv. Natural Gas Pipeline Corridor

The emissions of the natural gas pipeline corridor during closure were “anticipated to be similar to those presented for the construction phase, because the activities are similar in a given year.” Further, impacts would be comparable between Alternative 1a and 3. Therefore, the pipeline would likely generate approximately the same emissions as its construction, 1,332 metric tons of CO2-eq per year, during the 20-year closure period.

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129 U.S. Army Corps of Engineers, 23.
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